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ECL 261

INNOVATIVE TECHNIQUES FOR MANAGING WATER SUPPLY

Gary IMM

A study of the efforts of the Washington Metropolitan Area to solve its water supply problem through better management of existing resources. The technical issues are examined along with associated social and political interactions.

A Case Produced Under the WISE Program

ECL 261

Educating Prospective Engineers for Public Policy

INNOVATIVE TECHNIQUES FOR MANAGING WATER SUPPLY

by

Gary Imm[1]

February, 1985

Prepared as part of the 1983 Washington Internships for Students of Engineering (WISE) Program under the supervision of Dr. Barry Hyman[2]. All opinions presented are those of the author and do not in any way represent those of other individuals or institutions referred to in the text.

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TABLE OF CONTENTS

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Gary Imm

INTRODUCTION

"Infrastructure" is a word which has rapidly become familiar to engineers throughout this nation during the past decade. Mention of this word almost immediately brings to mind the inadequacy of many of this nation's public works systems, among them a large number of water supply systems. Everyone agrees that within the next decade there will be tremendous shortages in water supply and that vast improvements need to be made, but nobody seems to know where all of the money needed to pay for these improvements will come from. The following case is the story of engineers who solved their water shortage problem by taking a new approach to water supply--improvements made not by new construction, but by better management of existing resources.

This case documenting the problems of the Washington Metropolitan Area water supply examines how engineers must deal with both the technical and political aspects of an engineering dilemma. For ease of understanding this case is divided into six parts. Part A details the history of the problem and previously proposed solutions which have been rejected because of political opposition. Parts B,C and D study three independent projects which each greatly contributed toward a final solution, though each one could not have possibly solved the problem individually. Part E shows how a technical solution was achieved through coordination of previous projects and cooperation of the local utilities, and Part F documents implementation of the solution and how it was politically accepted. It should be remembered that although a few people are mentioned by name in this study, the size limitations of this paper make it impossible to mention the hundreds of others who were indirectly involved in development of the solution.

PART A: DEFINITION OF THE PROBLEM

The Basic Dilemma

Many events which have shaped the history of this nation have occurred within the boundaries of the Potomac River Basin. The Potomac River and its tributaries flow through such legendary places as Gettysburg, Harpers Ferry, Mount Vernon, and our nation's capital. Residents of its banks are proud of the fact that the basic nature of the Potomac River has remained unchanged since colonists settled here, with the exception of Bloomington Dam which is located near the headwaters of the Potomac River System. In fact, Washington, D.C. is the only large American metropolitan area that is predominantly dependent on a free-flowing river for its water supply. Unfortunately, Washington is also one of three major areas in the northeast section of this country identified by the Corps of Engineers as having critical water supply problems. These two facts are not coincidental. They are intertwined in a dilemma which has faced engineers for many years -- is it possible to develop a river into a dependable water resource while maintaining its natural, free-flowing state?

Safe Yield Concepts

Before discussing the existing water resources of the Washington Metropolitan Area (WMA), the theory of safe yield should be understood. Safe yield of a reservoir is generally defined as the constant rate of withdrawal which will just empty the reservoir given a repeat of the worst drought in the historical record. During drawdown, withdrawals exceed inflows, and the minimum storage (when the reservoir is empty) occurs just as inflows begin to exceed withdrawals. The critical period for safe yield analysis on the reservoirs in this study is approximately nine months. The safe yield of a river is defined simply as the historical low flow of the river. The concept of safe yield has been used for decades in determining the amount of water available for water supply. Following is a bleak safe yield comparison of existing WMA supplies versus the demand that must be met.

Existing Water Resources

In 1977, engineers of the WMA had five sources of water to draw upon, four reservoirs and a river, as shown in Exhibit A-1. Bloomington Reservoir, scheduled for completion in 1981 but incorporated into all studies since its authorization in 1971, supplies a safe yield of 135 million gallons per day (mgd). The Potomac River, in operation with Savage Reservoir, provides a safe yield of 388 mgd. (Savage Reservoir was in operation on September 13, 1966, when the minimum one-day flow of 388 mgd was recorded at

a Potomac River paging station. Since that record low flow the safe yield of the Potomac River and Savage Reservoir jointly has been taken as 388 mgd. In general, however, Savage Reservoir is considered mainly as a water quality control resource augmenting releases from Bloomington Reservoir.) The net safe yield for water supply of the reservoirs on the Patuxent River is 35 mgd, while Occoquan Reservoir supplies 55 mgd. These totals, with 100 mgd subtracted for minimum flowby at Washington, is shown in Exhibit A-1 to be 513 mgd.

Supply vs. Demand

In 1977 over ninety percent of the WMA was served by three major water utilities, the Fairfax County Water Authority (FCWA), the Washington Suburban Sanitary Commission (WSSC), and the Washington Aquaduct Division (WAD), as shown in Exhibit A-1. The FCWA serves counties in Northern Virginia solely from an intake on the Occoquan Reservoir. The WSSC serves southern Maryland from two intakes, one on the Potomac River and one on the Patuxent Reservoirs. The WAD is entirely dependent for its water supply from two intakes, both on the Potomac River.

The average demands on these WMA utilities during the summer of 1977 ranged from 450 to 470 mgd, with peak demands well exceeding these figures. In fact, peak demands during the past ten years had exceeded the previously mentioned safe yield of 513 mgd over a hundred times. Luckily the peak demands never coincided with low Potomac flows, or many residents within the WMA would have been without water.

In 1977 the future outlook for the WMA water supply system was as illustrated in Exhibits A-2 and A-3. Water shortages would soon occur within the system even if the Potomac were at average flow, and by the year 2020 deficits would be tremendous. The same year in which these dismal forecasts were predicted — 1977 — FCWA nearly emptied Occoquan Reservoir and Fairfax County pondered closing schools and businesses to conserve water. This situation led to the realization that a solution needed to be found soon, and local engineers responded by searching for a solution.

Previously Unsuccessful Proposals

This desperate situation which faced WMA engineers in 1977 was not a recent development. For thirty previous years an adequate solution had been searched for but never found. Most of the prior proposals emphasized the traditional "big dam" approach to water supply problems adopted by the Corps of Engineers. The first major proposal was drafted in 1963, including sixteen large reservoirs to be established throughout the Potomac River Basin as shown in Exhibit A-4. Though this plan also emphasized water quality and soil conservation, it was quickly squelched by immense public opposition in both the economic and environmental sectors. Subsequent proposed solutions have included well fields, recycling

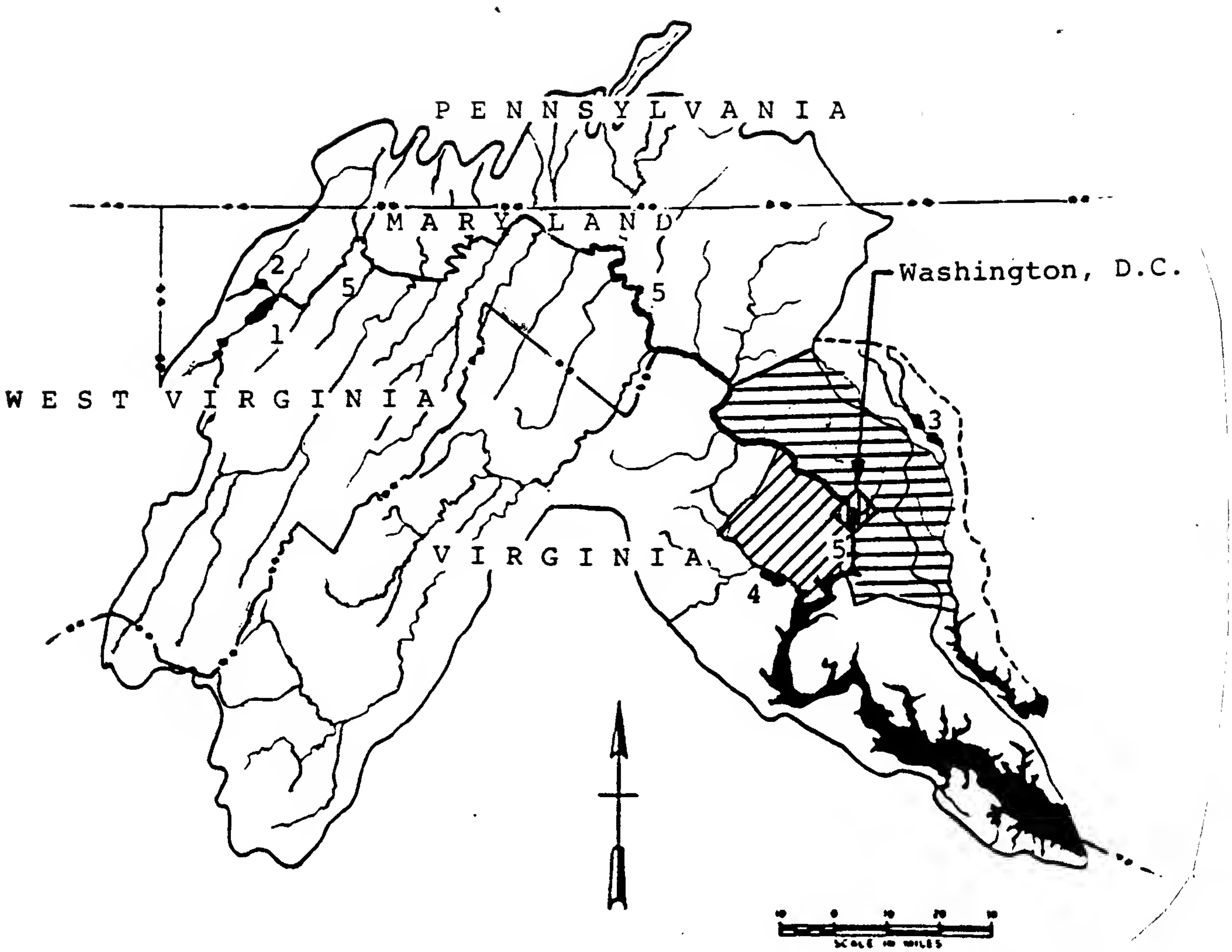
of estuarine water containing a substantial proportion of treated wastewater, high flow skimming, raw and finished water interconnections, and other projects ranging in cost between $200 million and $1 billion in 1983 construction dollars. It must be stressed here that although all these proposals were adequate solutions to the engineering aspect of the problem, all failed because of intense public opposition to both the high costs and the large amount of fertile land which would have gone under water.

Public Involvement

As a result of the rejection of all of these plans because of public opposition, the Corps of Engineers initiated a public information and participation program of water supply for the WMA. An important aspect of this program was the public opinion survey conducted in mid-1977, which produced two helpful and fairly surprising recommendations. One discovery was that "there is a more definite desire for solving water supply problems locally, rather than in going to formerly identified upstream sites as sources for solving water supply problems."[1] This was a finding which would affect all future studies of the problem. The other public recommendation was to integrate water conservation into any final solution. Almost ninety percent of all who responded to the survey revealed that they would make conservation a habit during a shortage. Thus it appeared that the public desired a local solution to the problem and were willing to sacrifice excessive water use to do so. The only problem was that no feasible local solutions were under consideration at this time.

The Outlook

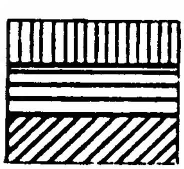
In 1974, for the third time in three decades, the United States Congress directed that a thorough investigation be made of existing and future water supply needs of the WMA, and that recommendations be made to the U.S. Congress satisfying such needs. This direction is shown in Exhibit A-5, especially in paragraph (b) (1). Three years later, in 1977, local engineers were facing a major problem. Not only did they again have to submit a report to the Congress of the United States of America, but now the public desired a local solution to the problem when there were none under consideration. Most importantly, the residents of the WMA still faced the immediate possibility of being without water. The outlook was not good.



Legend

Resource	Available Storage (MG)	Safe Yield (MGD)
1 Bloomington Reservoir	30,000	135
2 Savage Reservoir	5,900	-
3 Patuxent Reservoirs	10,100	35
4 Occoquan Reservoir	10,300	55
5 Potomac River	-	388
		613
	Minimum Flowby	-100
	Total Safe Yield	513

WMA Water Service Areas



Washington Aquaduct Division

Washington Suburban Sanitary Commission

Fairfax County Water Authority

Exhibit A-1

Potomac River Basin

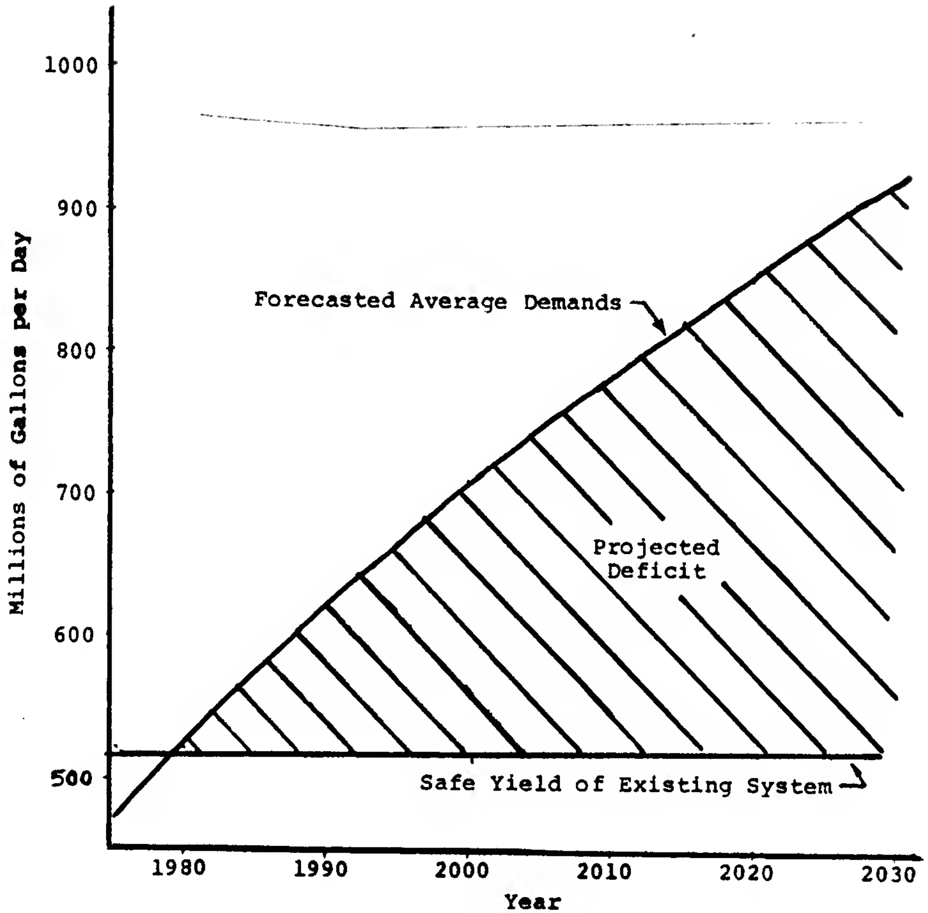


Exhibit A-2

Situation Facing WMA Engineers in 1977

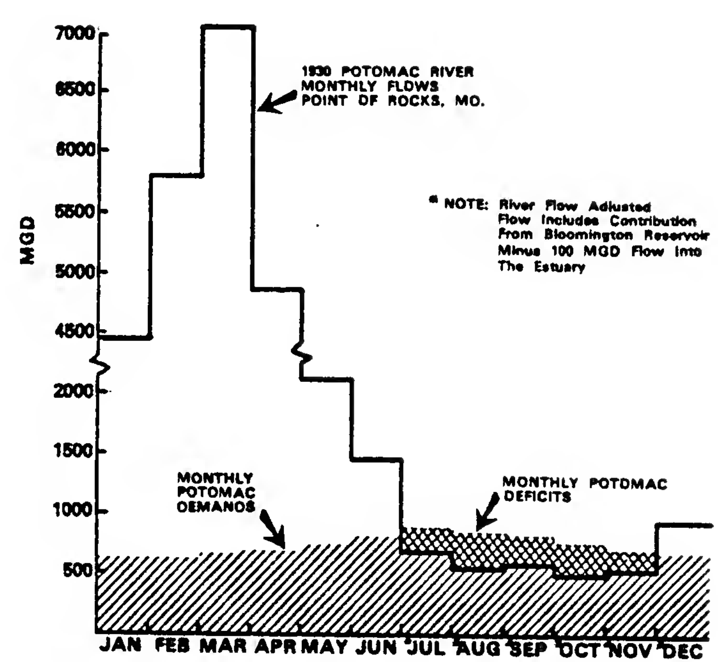
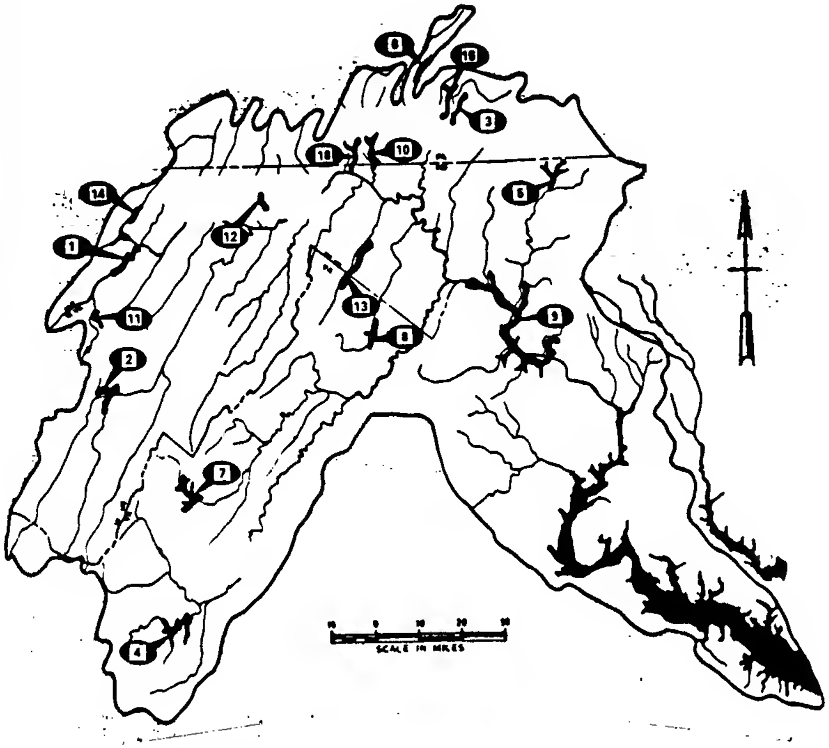


Exhibit A-3

Projected Regional Supply, Demand, and Deficits for 2020



LIST OF MAJOR RESERVOIRS

1	Bloomington	9	Seneca
2	Royal Glen	10	Licking Creek
3	Chambersburg	11	Mount Storm
4	Verona	12	Town Creek
5	Sixes Bridge	13	North Mountain
6	West Branch	14	Savage II
7	Brocks Gap	15	Back Creek
8	Winchester	16	Tonoloway Creek

Exhibit A-4

District Engineer's Recommendations, 1963

" SEC.85. (a) The projects for Verona Dam and Lake, Virginia, and for Sixes Bridge Dam and Lake, Maryland, are hereby authorized substantially in accordance with the recommendations of the Secretary of the Army in House Document Numbered 91-343 as modified by the recommendations of the Chief of Engineers in his report dated July 13, 1973, except that such authorization shall be limited to the phase I design memorandum of advanced engineering and design, at an estimated cost of $1,400,000.

(b)(1) Prior to any further authorization of such Sixes Bridge Dam Project, the Secretary of the Army, acting through the Chief of Engineers shall (A) make a full and complete investigation and study of the future water resources needs of the Washington metropolitan area, including but not limited to the adequacy of present water supply, nature of present and future uses, the effect water pricing policies and use restrictions may have on future demand, the feasibility of utilizing water from the Potomac estuary, all possible water impoundment sites, natural and recharged ground water supply, wastewater reclamation, and the effect such projects will have on fish, wildlife, and present beneficial uses, and shall provide recommendations based on such investigation and study for supplying such needs, and (B) report to the Congress the results of such investigation and study together with such recommendations. The study of measures to meet the water supply needs of the Washington metropolitan area shall be coordinated with the Northeastern United States water supply study authorized by the Act of October 27, 1965 (79 Stat. 1073).

(2) The Secretary of the Army, acting through the Chief of Engineers, shall undertake an investigation and study of the use of estuary waters to determine the feasibility of using such waters as a source of water supply and is authorized to construct, operate, and evaluate a pilot project on the Potomac estuary for the treatment of such waters at an estimated cost of $6,000,000. The Secretary of the Army, acting through the Chief of Engineers, shall report to the Congress on the results of such project within three years after commencement of operation of such project and such report shall include the results of two years testing at the pilot project for the treatment of water from the Potomac estuary.

(3) The Secretary of the Army, acting through the Chief of Engineers, shall request the National Academy of Sciences-National Academy of Engineering to review and by written report comment upon the scientific basis for the conclusions reached by the investigation and study of the future water resource needs of the Washington metropolitan area and the pilot project for the treatment of water from the Potomac estuary. Such review and written report shall be completed and submitted to the Congress within one year following the completion of both the Corps of Engineers report on the future water resource needs of the Washington metropolitan area and the report on the results derived from the pilot project for the treatment of water from the Potomac estuary. Completion of such review and written report by the National Academy of Sciences-National Academy of Engineering shall be a condition of further authorization of such Sixes Bridge Dam Project.

(4) The Secretary of the Army is authorized to enter into appropriate arrangements with the National Academy of Sciences-National Academy of Engineering for the purpose of this subsection.

(c) There is authorized $1,000,000 for the purposes of carrying out the provisions contained in paragraph (3) of subsection (b)."

Exhibit A-5

Section 85
Water Resources Development Act of 1974

PART B: THE REREGULATION CONCEPT

Introduction of Dan Sheer and ICPRB

The year in which the United States Congress passed a bill authorizing the study on the water resources problem of the WMA, 1974, was the same year that Dan Sheer graduated from Johns Hopkins University with his doctorate. His degree is in environmental engineering, and the subject of his thesis was economic sequencing of public works facilities. His thesis studied the sixteen reservoir proposal of the Corps of Engineers, and after graduation he used this knowledge upon accepting a job offer from the Interstate Commission on the Potomac River Basin (ICPRB).

ICPRB was authorized by Congress in 1940 for the purpose of "regulating, controlling, preventing, or otherwise rendering unobjectionable and harmless the pollution of the waters of said Potomac drainage area by sewage and industrial and other wastes."[2] This authorization was broadened in 1970 to include water resources management. Dan was analyzing wastewater flow in fulfillment of this charter when he and his colleagues arrived at some surprising conclusions concerning the WMA water supply problem.

The Breakthrough

Dan recalls how the breakthrough was made:

> In 1977, I was working for COG (Council of Governments, which serves the WMA in conjunction with ICPRB) on water quality management planning and came to some surprising conclusions about WMA water supply problems. The question of how much water there would be coming over Little Falls (a point on the Potomac just above Washington) into the estuary had to be resolved. This was needed for modeling runs for waste load allocations. Since demands on the river equalled the 7-day 10-year low flow, the answer was nothing. Thinking about it, the water coming over Little Falls has some pollutants. If these are routed through the treatment plant, at least some will be removed. If that is true, then maybe the utilities should operate to maximize Potomac River withdrawals all the time. That meant taking as much water from the Potomac as possible and reducing withdrawals from local reservoirs. Such an operation would save a lot of water in the local reservoirs. How much?[3]

Dan began with searching for a solution to a water quality problem, and ended with a legitimate water resources question -- how much water could be saved and stored in local reservoirs if Potomac River withdrawals were maximized?

Dan knew that previous studies using independent safe yield analysis had shown that there was not nearly enough water in the Potomac River Basin to meet potential demands. This new idea which Dan proposed completely abandoned the concept of independent safe yield operations of local reservoirs, concentrating instead on the maximum yield which could be derived if both the Patuxent and the Occoquan Reservoirs were operated in coordination with the free-flowing Potomac. In other words, Dan suggested that a system analysis be done using joint operations.

Surprising System Analysis Results

System analysis compares the total volume of water needed for public demand against the volume of water which can be supplied by the system. Dan's system analysis utilized water requirement forecasts for the year 2000, projected to be at most 750 mgd. The 90-day long 50-year recurrence interval (90-Q-50) low flow in the Potomac River System (including Savage and Bloomington Reservoirs) is 580 mgd. (The reason that the 90-Q-50 flow was used is because this interval created the largest deficit, as shown in Exhibit B-1.) The largest total deficit possible, over a 90-day period, would then be:

$$\begin{array}{rcrcl} 750 \text{ mgd} & \times & 90 \text{ days} & = & 67.5 \text{ billion gallons} \\ -\ 580 \text{ mgd} & \times & 90 \text{ days} & = & 52.5 \text{ billion gallons} \\ \hline & & \text{Deficit} & = & 15 \text{ billion gallons} \end{array}$$

However, storage in the Occoquan and Patuxent Reservoirs totals over 20 billion gallons, as shown in Exhibit A-1. The conclusion of Dan and ICPRB was that the WMA was not short of water if it could only efficiently manage the existing storage.

Reregulation

This local, inexpensive proposed solution to the problem inspired the Corps of Engineers to fund an ICPRB in-depth analysis of how to efficiently manage the WMA water system. The first alternative that they investigated was raw water interconnections — large pipelines which would transfer water back and forth from reservoirs to river, depending on which area had a surplus or a shortage of water. This idea, though technologically sound, proved to be much too expensive.

The second alternative which was studied was a concept called "reregulation." Reregulation, as exemplified in Exhibit B-2, involves distribution of water within a given service area which is served by both a river and a reservoir source, each with an independent water treatment plant. During times when the river is at normal flow or higher, most of the distribution area is served by the river source, thereby conserving reservoir storage. This reservoir storage of water is utilized during times of low

flow from the river (principally in the fall) when most of the distribution area is served by the reservoir, thereby conserving river water for a different utility downstream whose only intake is on the river.

ICPRB liked the reregulation concept because it made the best use of the existing facilities, could theoretically be implemented at almost no cost, and was a local solution to the WMA water supply problem. Before this theory could be put into practice, however, the service areas of the FCWA and the WSSC needed to be examined to see if each could handle distribution from two sources, a river and a reservoir.

Distribution System Analysis

Before the reregulation theory could be used the existing distribution systems needed to be studied with respect to pipe and treatment plant size. Of particular concern was whether the pipes and treatment plants close to the river could handle the pressure and volume of water needed to serve houses near the reservoir so that reservoir water could be conserved, and vice-versa.

ICPRB performed the analysis and presented conclusions which surprised everyone. First of all, with respect to the pipe capacity, they found that no new distribution lines were needed. The existing systems, with the addition of an intake on the Potomac River for the FCWA, could be operated so as to ensure the availability of water to all customers during reregulation operation.

Dan was not as surprised as others were at these results. He knew that the major parts of the distribution systems are designed for peak demands of 160% of the WMA average, which occur infrequently. The smaller system components are designed to accomodate fire flows, and consequently also have a high capacity. This excess capacity in the distribution pipes can be depended upon to accomodate flexible operating rules designed to maximize yield.

The second concern was that the treatment plants at the location where high flows of water need to be pumped might not be able to handle the larger flow. However, the ICPRB study showed that minimum flows in the Potomac River usually occur in fall and do not coincide with the July and August peak demands. This means that when full capacity operation of the reservoir treatment plants is needed only average demands have to be met, therefore intake ceilings are not a major constraint to reregulation operation.

Utility Reaction to the Reregulation Theory

The WSSC and the FCWA, the two utilities capable of imple-

menting reregulation, were contacted and immediately indicated that they would use this new procedure. As soon as FCWA could complete their Potomac River intake both utilities would practice reregulation, leaving the WAD, the only utility with no reservoir intake, with enough water downstream to supply to its customers. As a result, the yield of the Patuxent Reservoirs increased from 35 to 65 mgd (which is plant capacity) and the Occoquan Reservoir yield jumped from 55 to 112 mgd. This amounted to a 100% increase in local reservoir yield of nearly 90 mgd, which brought the total net WMA yield to 610 mgd.

The reason why local reservoir safe yields were increased using system operations is simple. The critical period for safe yield analysis on the local reservoirs is about nine months. The period for which flows in the Potomac have been lower than demands is much shorter, about four months; it is a much larger river than those that feed the local reservoirs, and the demands are a much smaller percentage of the average flow. Therefore the increase in safe yield amounts to taking water from the reservoirs at a higher rate, but for a shorter time (four months instead of nine). The volume of water taken is still the same.

This theory of reregulation increased tremendously the safe yield output of the local reservoirs, and was the first step towards a publicly acceptable solution in almost thirty years. In reality, though, the WMA's demands were only met through 1990 (as shown in Exhibit B-3), and there were still no long-term solutions in sight.

The Bi-County Task Force

While Dan Sheer and his colleagues were examining the theory of reregulation, another important development was taking place in Maryland. Two Maryland counties within the WSSC service area, Prince George and Montgomery, were frustrated by the continuing failure of the Corps of Engineers to find a solution to the long-standing water supply problem. As a result, in 1976, these two counties and WSSC formed a Bi-County Task Force to solve their problems locally without federal help.

One of the most important contributions of the Task Force is the way in which it was organized. Engineers at WSSC knew that previous Corps of Engineers' proposals were theoretically sound but were rejected because of immense public and political opposition. The dilemma that WSSC now faced was how not to suffer the same fate.

Water Demand Projection
Year 2000

NEWS Study Monthly Demands*

July	August	September	Average Summer
771	755	723	750 mgd

* From NEWS Study Report, U.S. Army COE NAD, 11/75 p. 31. Figures for Potomac Demand Corrected by adding back 130 mgd assumed from Patuxent and Occoquan Reservoirs and assuming additional 10 mgd (total of 14 mgd) from Goose Creek and Beaverdam Reservoirs.

TABLE 1

TABLE 2

Drought Flows, Durations and Recurrence Frequencies*

ought Duration	Frequency of Recurrence 10 yr.	20 yr.	50 yr.
7 - Day	541	478	419
14 - Day	575	506	438
30 - Day	641	568	503
60 - Day	729	632	541
90 - Day	813	697	580
120 - Day	929	794	658

Flows in mgd at Point of Rocks, Maryland.

urce: Walker, Patrick N., Flow Characteristics of Maryland Streams, Maryland Geological Survey, 1971, p. 113.

TABLE 3

Total Water Deficits (billions of gallons, assuming no flow augmentatic from Bloomington)

Drought Duration	Frequency of Recurrence 10 yr.	20 yr.	50 yr.
7 - Day	1.4	1.9	2.3
14 - Day	2.5	3.4	4.4
30 - Day	3.3	5.5	7.4
60 - Day	1.2	7.1	12.5
90 - Day	0	4.8	15.3
120 - Day	0	0	11.0

The total water deficits in Table 3 were found by subtracting the drought flows in Table 2 from the average summer flow of 750 mgd in Table 1. For example, the 7-day 10 year deficit would be 1.4 BG because 750 mgd minus 541 mgd equals about 200 mgd, which when multiplied by 7 days gives 1.4 BG. The largest deficit is seen to be 15.3 BG, which was the number which Dan used in his calculations.

Exhibit B-1

Total Water Deficit Calculations

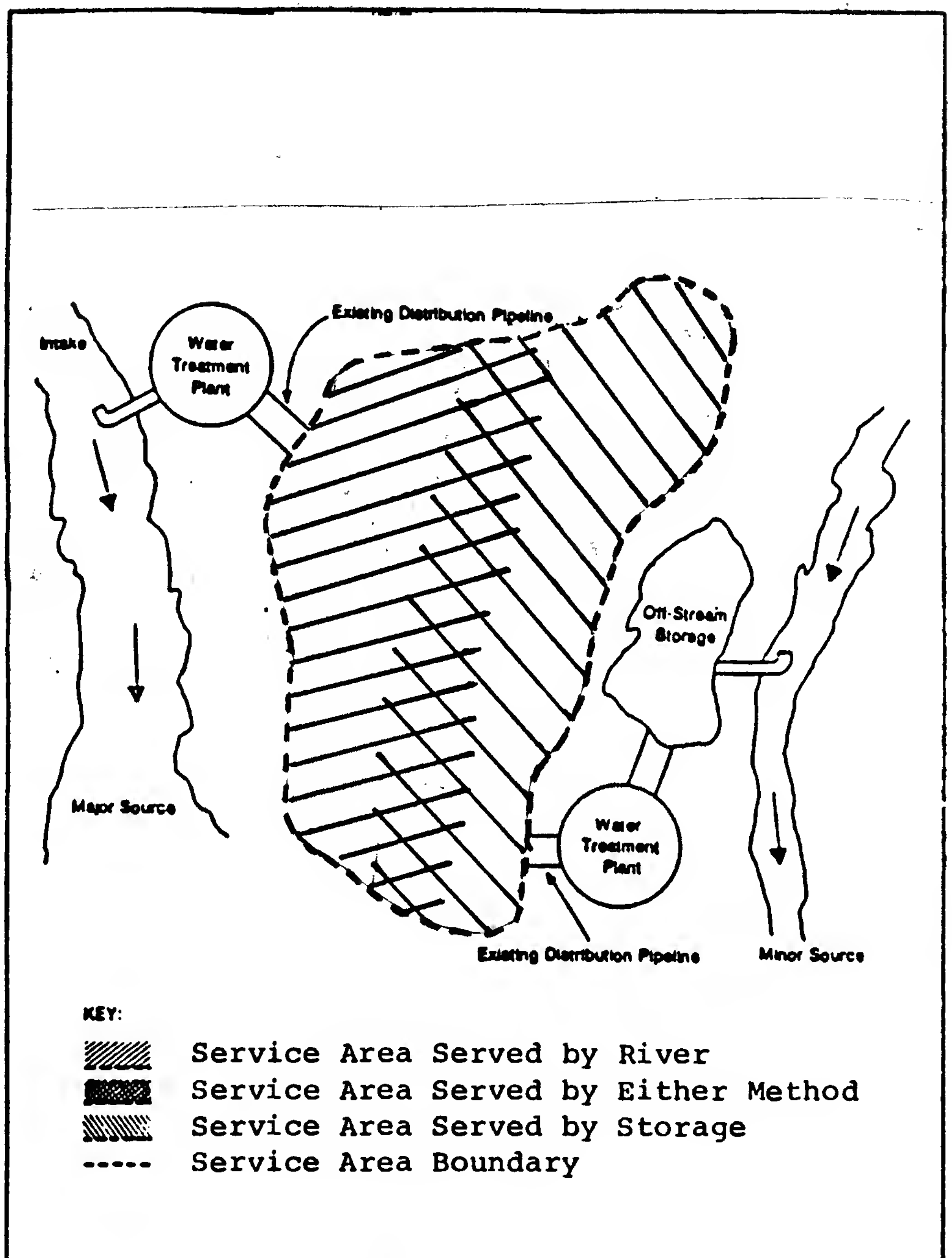


Exhibit B-2

Representation of Reregulation Theory

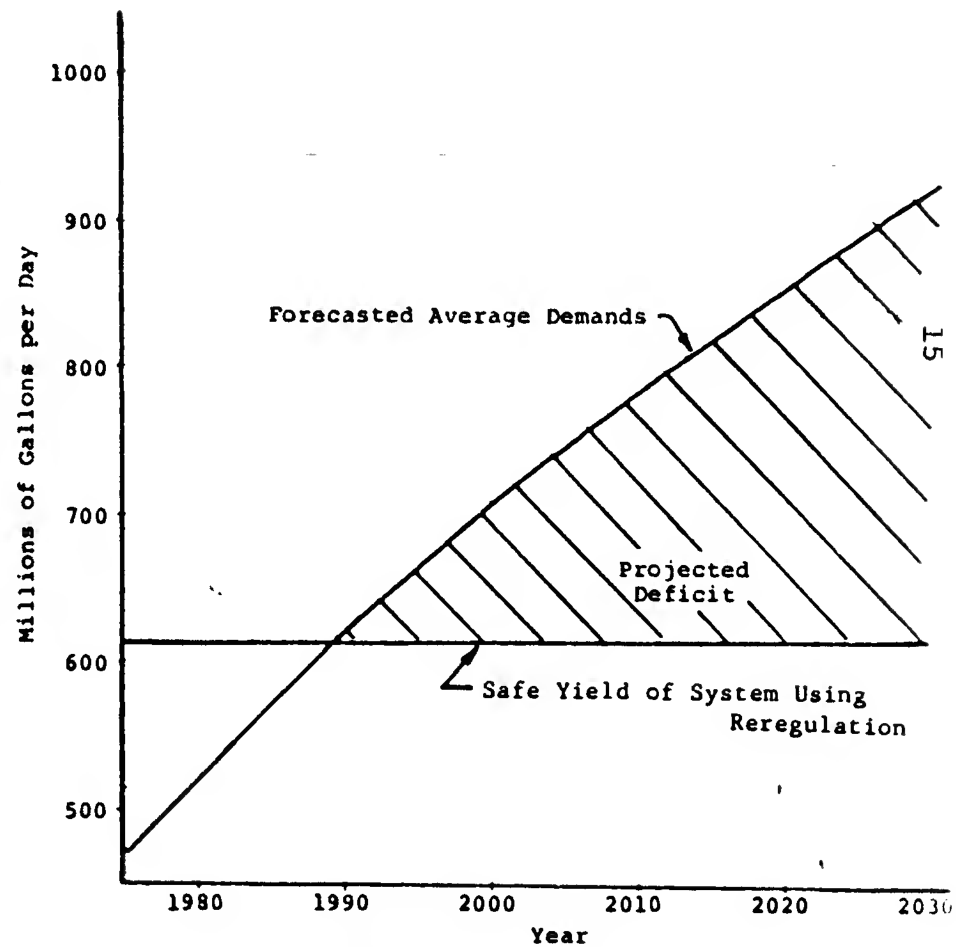


Exhibit B-3

Situation Facing WMA Engineers in Early 1979

PART C: CONTRIBUTIONS OF THE BI-COUNTY TASK FORCE

The Structure of the Task Force

Engineers at WSSC knew from previously rejected proposals that any solution they developed would have to be approved and financed by the local governments through the WSSC, and that if opposition arose the political leadership would receive the blame. Consequently, since the politicians of the WMA had been the ones in the past who ultimately decided the fate of previous proposals, it was decided by WSSC and the two counties that the Task Force should be composed of the political leadership of the two counties. In this way the appropriate officials were directly exposed to the engineering design process and able to reject immediately any projects that were politically unacceptable to their jurisdictions. This step had been ignored in past proposals, resulting in failure each time.

Two advisory committees were established to support the Task Force, a Citizens Advisory Committee and a Technical Advisory Committee. The Citizens Advisory Committee was important since the conclusions of the study were likely to be controversial, as others had been in the past. A broad-based public committee would be able to assist the political leadership of the two counties to obtain public support for any final decisions. The Technical Advisory Committee was appointed by WSSC and provided the engineering input needed by the Task Force.

The Leader -- Robert McGarry

Appointed as general manager of the Bi-County Task Force was Robert McGarry. Bob graduated with his B.S. in engineering from West Point in 1952, and received his graduate degree from Illinois in 1959. He had held numerous positions within the U.S. Army, including serving as District Engineer for the Corps of Engineers in charge of the Potomac River Basin until his retirement in 1977. At this time the WSSC, searching for an experienced man to head the Task Force, chose Bob as general manager. His services would have an enormous impact on not only WSSC's water supply problem, but, more importantly, the entire WMA water supply problem as well. Dan Sheer, talking of Bob, emphasizes:

> I think that he couldn't have done what he did without my help, but I know that I couldn't have done what I did without him.[4]

Drought Management

The first of two important concepts that were developed by the Task Force was that of drought management. Bob comments on what led to the Task Force's development of this approach:

> The size of the reservoirs (proposed in 1963 and

> later rejected) were based on the very conventional thinking of "Let's provide all the water we need for the worst day in the worst drought." Plenty of yield. As a result, the reservoirs were not only too large, with respect to environmental impact, but also too expensive.[5]

Bob knew that WSSC was only a local utility with limited funds, and decided that the WSSC should not plan to construct all of the facilities necessary during the worst of droughts. The prior public opinion survey indicated that the public was willing to conserve water, and Bob decided to use this willingness to everyone's advantage, as he describes below:

> A drought management plan with three stages (I, II, and III) was developed, each stage being a more severe restriction to manage water. During stage I, use of outside water is restricted. During stage II, air conditioning usage is restricted and swimming pools closed down. During stage III, consisting of steps III A, III B, III C, the restrictions become even more severe. The Task Force next decided what risk it was willing to accept and what it wanted to plan for. It was decided to accept scenario A (see Exhibit C-1). Basically, the commission will accept an eight percent probability that in any given year stage I (restricting use of outside water) will have to be implemented for less than 30 days and a five percent probability that it will have to be implemented for more than 30 days. The probability for implementation of stage II was determined to be fairly low (three percent), and that for stage III was considered almost unlikely. The impact of that, though, I think is the important thing. By adopting that kind of analysis the Task Force reduced the storage requirements by the year 2000 from 3,400 to 1,300 million gallons (see Exhibit C-1). About one-third of the storage is needed (one-third of the additional water) if you are willing to take the risk. Remember, political officials are going to have to defend this risk and take the heat if the public does not like restrictions when they are imposed. The elected officials did adopt drought management.[6]

This willingness to assume an increased risk of public inconvenience reduced the additional water requirement for the bi-county area substantially. Because of this the concept of drought management was incorporated into all subsequent WMA water supply studies.

Little Seneca Reservoir

The second important outcome of the Bi-County Task Force was

the recommendation to construct Little Seneca Reservoir as a local reservoir to help alleviate major water problems in times of drought. Little Seneca Reservoir is located within the jurisdiction of the WSSC near Washington, D.C., as shown in Exhibit C-2. With the incorporation of drought management there still would be a shortage requirement in the bi-county area during a drought of approximately 1300 million gallons, as shown in scenario A of Exhibit C-1. A local reservoir would supply additional water on short notice to meet shortages, as illustrated in Exhibit C-3, and would provide recreational benefits as well.

The two recommendations of drought management and Little Seneca Reservoir were well received both publically and politically. The WSSC obtained the approval of the recommendations from both counties, began design of Little Seneca Reservoir, and applied to the Corps of Engineers for the necessary construction permit. All of WSSC's water supply problems appeared to be solved only two years after the Task Force was authorized.

E.P.A. Action

Unfortunately in 1980 the United States Environmental Protection Agency, which routinely reviews proposed Corps permits, strenuously objected to construction of Little Seneca Reservoir. The letter from the E.P.A. recommending that no permit be issued is shown in Exhibit C-4. The objections centered on three potential problems: water quality problems in the reservoir; alteration of natural habitat; and, most unusual, the possibility that an independent solution to WSSC's water supply problem would foster environmentally disruptive independent solutions to the same problems faced by the other utilities in the Potomac River Basin.

To phrase it mildly, Bob was not at all happy with the results of the E.P.A. permit review. The first two objections he had somewhat expected, since many eventually approved reservoir sites also had to face up to these problems in the design process. The last objection was his big problem — objection to construction of a reservoir site because approval of construction might spur other utilities to construct more reservoirs which might be environmentally disruptive. Bob did not believe that the E.P.A. had any legal foundation to uphold what they had said, but he knew that a court settlement of the issue could take years. Also, the E.P.A. stated that a comprehensive drought plan would eliminate WSSC's deficit, when the figures from scenario A indicated that there would be a deficit of at least 1,000 million gallons.

Now, after two years of encouraging development over a thirty year problem, Bob and WSSC were right back where they started from because of unprecedented E.P.A. action.

	PERCENT PROBABILITY THAT A STAGE WILL BE IMPLEMENTED IN ANY GIVEN YEAR		STORAGE REQUIREMENTS (MG)		
	<30 days	>30 days	1985	1995	2005
Scenario A					
Stage I	8%	5%			
II	3%	2%			
III-A	1%	1%	0	850	1,320
III-B	1%	1%			
III-C	1%	1%			
Scenario B					
Stage I	20%	17%			
II	10%	5%			
III-A	1%	1%	0	430	740
III-B	1%	1%			
III-C	1%	1%			
Scenario C					
Scenario C assumes no restrictions on water use.			250	2,250	3,400

Exhibit C-1

Risk Analysis and Storage Requirements for the Bi-County Area Scenarios

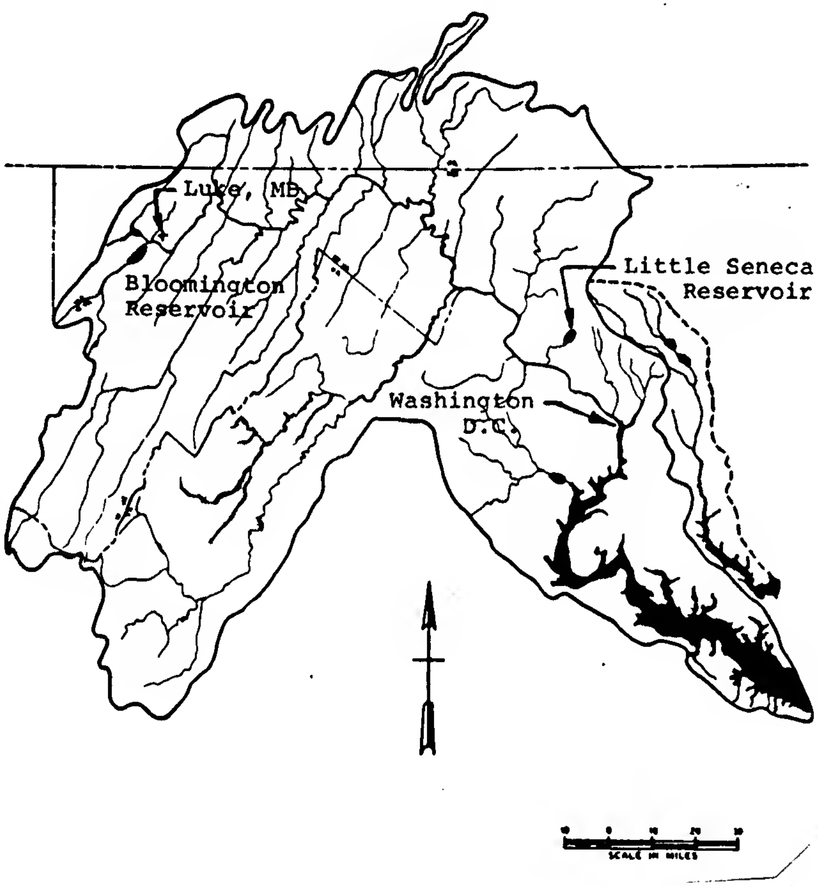


Exhibit C-2

Map Showing Location of Luke, Maryland and Little Seneca Reservoir

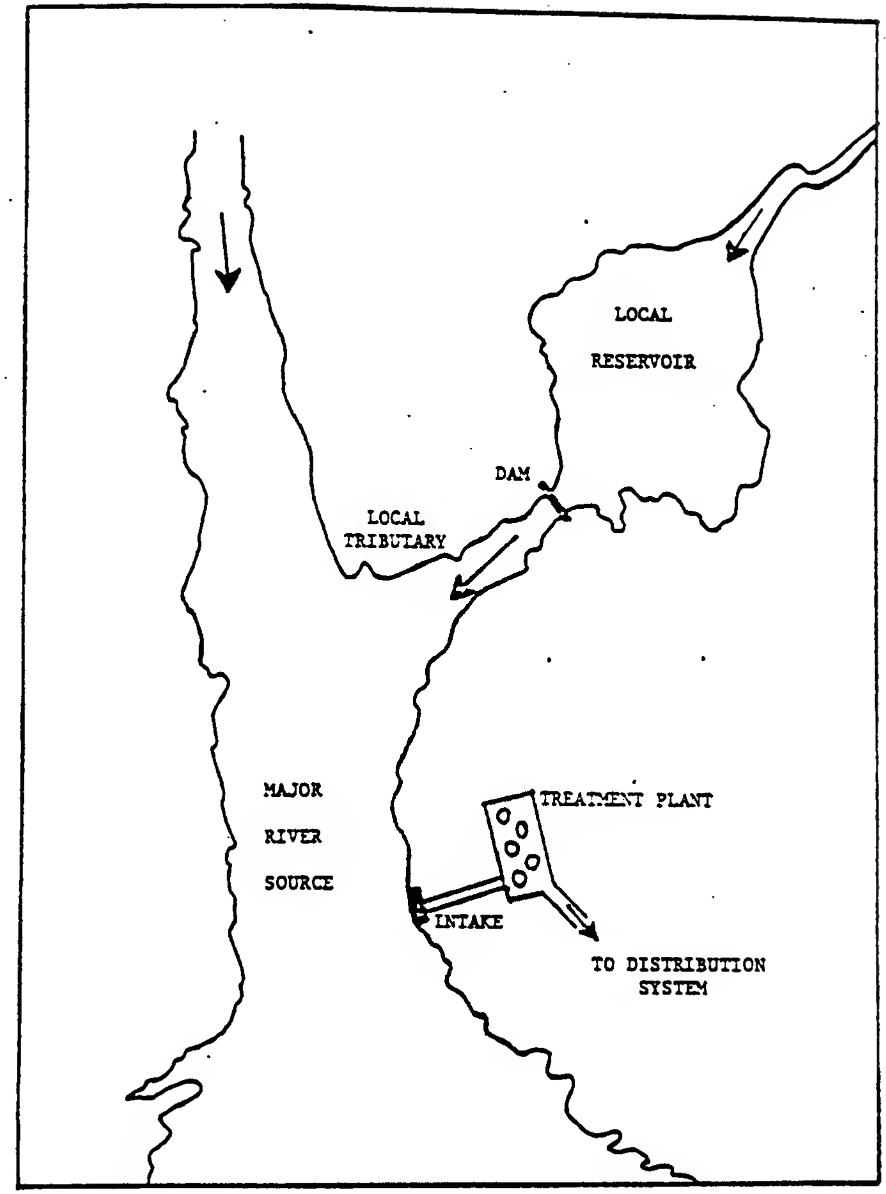


Exhibit C-3

Illustration of Local Reservoir Operation

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION III

6TH AND WALNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

SEP 3 1980

RECEIVED
PROJECT MANAGEMENT
SEP 12 1980
WASHINGTON SUBURBAN
SANITARY COMMISSION

Mr. Donald W. Roeseke
Chief, Regulatory Functions Branch
Baltimore District
Corps of Engineers
Post Office Box 1715
Baltimore, Maryland 21203

Re: NABOP-FR (Washington Suburban Sanitary Commission) 80-0186, May 30, 1980

Dear Mr. Roeseke:

We received the above referenced Public Notice describing an application for work in navigable waters, as well as the Environmental Assessment, the draft Project Development Report, and the Bi-County Water Supply Study which describe the proposed project in detail. We considered the water pollution potential of the project as well as other possible environmental effects resulting from construction of the facility. The project will create unacceptable water quality impacts. Therefore, we recommend that the project be denied and that no permit be issued.

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•
•

There are alternatives to the proposed project which would meet the water supply needs of the area without creating the adverse impacts associated with the Little Seneca Lake Project. Furthermore, it is highly likely that one or more of these alternatives will eventually be undertaken as part of the regional solution currently being developed. Since WSSC has projected that a comprehensive drought management plan would eliminate their deficit, we believe that the implementation of these water conservation measures during the infrequent droughts is a more feasible short term solution to their water supply needs. We also believe that they should redirect their efforts at developing an alternative that would help to solve the regional problem. Allowing the construction of this dam as a localized, short term water supply solution would be an unfortunate precedent for other authorities and would result in a significant loss of natural resources.

•
•
•

Please advise us of any action taken on the above permit request.

Sincerely yours,

John R. Pomponio

John R. Pomponio
Chief
EIS & Wetlands Review Section

Exhibit C-4

Excerpts from the E.P.A. Letter Sent to the Corps of Engineers

PART D: THE PRISM MODEL

Development at Johns Hopkins

The third important development essential to the solution of WMA's water supply problem occurred within a year of the studies done by Dan and Bob. In September of 1977, a research team at Johns Hopkins University was awarded a matching funds grant from the U.S. Department of the Interior, the Office of Water Research and Technology, the Commonwealth of Virginia, and the State of Maryland. This funding package was assembled by ICPRB, the organization for which Dan worked. It was hoped that, with the recent advances in operations research and the improved capability for computer simulation of complex systems, a computer model of the WMA water supply system might be beneficial to all parties involved.

Bloomington Dam Releases

A team of graduate research assistants performed the analysis, primarily investigating future operating rules for Bloomington Dam which would increase its yield for water supply. The construction of Bloomington Dam was begun in 1971 and completed in 1981. All water supply studies performed since 1971 assumed integration of Bloomington into any future water plan, with the dam regulated to maintain a continuous flow of 197 mgd through Luke, Maryland (see Exhibit C-2) as suggested in the 1962 authorization document. However, Johns Hopkins found that a continuous flow of 197 mgd at Luke would be very inefficient from a water supply viewpoint and detrimental to the water quality in the Potomac as well. Their study indicated that small reductions in upstream reservoir release resulted in tremendous gains in system yield. The graph in Exhibit D-1 illustrates this, showing the tradeoff between the amount of upstream reservoir release and the number of years past 1980 that the WMA system could safely provide enough water, assuming perfect forecasting.

System Analysis Results

In addition to analyzing upstream releases, the team also developed an interactive simulation model and used linear programming techniques to establish the highest yield possible for the entire Potomac River Basin. Not only did they utilize their release pattern for Bloomington Dam, but they also incorporated Dan's concept of reregulation of local reservoirs. The results were astounding. Assuming perfect forecasting of demand and Potomac flow on a weekly average basis, the theoretical upper bound was a yield of over one-thousand mgd, in contrast to the previously perceived limit of five hundred mgd. It must be remembered that this encouraging figure was determined by abandoning independent safe yield analysis, instead concentrating on the total volume of water contained in the Potomac River Basin.

The PRISM Model

Naturally the managers and operators of the local utilities

found these optimistic figures hard to believe. To help them overcome their understandable doubts, the team developed the Potomac River Interactive Simulation Model (PRISM). PRISM was essentially a computer game to be played by the operators. At the heart of this game was a reasonably realistic weekly simulation model of reservoir and utility operations. The computer provided the players with the same type of information that they would have to work with during a real drought and asked them to respond by making operational decisions, some of which are shown in Exhibit D-2. The effects of these decisions on how much water to release from the reservoirs and how much water to intake for distribution were then combined with other factors -- predicted water demand, forecasted weather conditions, and time of year -- to produce simulated results. A primitive flowchart of basic operational decisions made by the PRISM model is shown in Exhibit D-3.

Difficulties in Playing Computer Games

At first the utility operators found it difficult to make the right decisions to keep water shortages from occurring and the amount of wasted water to a minimum. The operators became better with time, though, and soon discovered that the main reason for a major water shortage was not inaccurate prediction of public water demand or basic river flow -- it was the age-old problem of how to forecast the weather.

Water takes almost a week to flow from Bloomington Dam to the WMA, and it was difficult to predict in advance how much rain would fall during that time. Releases made a week in advance and predicted on a forecast of no rain were almost always too large; rain would fall sometime during the week, somewhere in the 11,000 square mile basin. This extra water flowed past the WMA intakes unused and wasted. If releases from Bloomington were based on a forecast of rain, inevitably no rain fell and large shortages developed. The best part of the PRISM model was that it showed these problems, and it also convinced the operators that if their forecasts were accurate there would be plenty of water for all even during a drought. The PRISM model graphically illustrated the problems of release forecasting and the benefits of cooperative reservoir operation, without having to suffer through physical operations during a real drought to understand the intricacies of the system.

The Corps Takes Over

The Army Corps of Engineers realized that PRISM was a valuable tool and adopted it to their own use. Using lessons learned from the model and incorporating the concept of reregulation, the Corps released a report in 1979 which was radically different from the large dam (or damn, if you were a land-owner) building policies of recent decades. Within this study, the WMA Water Supply Progress Report, the Corps emphasized specific solutions to the WMA's problems. There were two solution proposals which generated the highest amount of interest, labelled the local plan and the regional plan.

The Local Plan

The local plan utilized minimal regional cooperation. The unique aspect of this plan was that each project would be operated independently to satisfy water needs in the individual service areas, and each project could be financed separately by the water utility it served. The Potomac would serve mainly the WAD; Occoquan Reservoir would serve FCWA; and the Patuxent and Little Seneca (if E.P.A. permission could be secured) Reservoirs would serve the WSSC.

The Regional Plan

This plan took the final step towards regional cooperation by assuming that all projects would be shared equitably, with regard to both benefits and costs. The total Potomac flow would be divided among the three utilities according to an agreement which was signed by the local utilities in 1977, the Low Flow Allocation Agreement (LFAA). The logic behind this agreement, which stipulated that all water be proportionately shared by the utilities in times of drought, would be carried further to include water-sharing during non-drought conditions. A comparison of these two plans is shown below.

Local	Regional
Minimal Regional Cooperation	Total Regional Cooperation
Components Sized to Meet Individual Service Area Needs	Components Sized for Entire System; New Projects Brought On-line Only As Needed By Region
Projects Operated Independently	Projects Operated Jointly
Projects Financed Independently	Projects Financed Jointly
Structural Differences:	
Potomac to Occoquan Raw Water Interconnection Built in 1994	Potomac to Patuxent Raw Water Interconnection Built in 2017
Cost Differences (based on 50-year plan):	
Total Cost= $4,620,000/year	Total Cost= $3,310,000/year
Identical Conservation Measures Implemented in Each Plan	

Thoughts on Which Plan to Choose

The Corps noted that the regional plan which emphasized regional cooperation in operations and construction would greatly reduce cost, but noted the potential difficulties in reaching the necessary agreements. This pessimism is reflected in the following quote from the Corps' report:

Plan 2 (the local plan) was chosen as the plan

> which would be most likely in the absence of any coordinated regional plan, and this plan was used as the basis for comparison. Despite the fact that this plan represents a more costly plan than other action plans available, it is the most likely one to be implemented by the local utilities. This is because it requires less regional cooperation than the other plans and because it contains other projects which are actively being planned for.[7]

The Corps introduces its chapter on "Problems of Implementation" in the Main Report with the following quote:

> If the Washington area cannot agree on regional cooperation in water and sewage treatment, it is because we are in a prisoners' dilemma — each could gain by regional cooperation but no way exists to insure that all would cooperate.[8]

The former chairman of ICPRB, Mrs. Loretta Nimmerrichter, in her opening remarks to the Thames/Potomac seminar, stated:

> One thing that this seminar is not is another attempt to promote a powerful compact for the Potomac, a proposal which has failed to materialize after ten years of vigorous promotion. Almost the opposite is true. For this exchange is taking place at an exciting time in the Potomac basin, when local government seems to be coming alive again, and showing a renewed determination to assert its rights and assume its responsibilities.[9]

Though the regional plan appeared the best plan on paper, most people doubted that it had any chance of being implemented.

Two Major Problems

As of 1979 two major problems stood in the way of a solution to the WMA's water supply problem. First of all, the problem of wasted water from Bloomington Dam releases had to be corrected. There was no way that there would be enough water if the WMA consistently permitted water to flow by its intakes unused. Secondly, even if this first problem was resolved, there was no guarantee that the local utilities would cooperate to pay for and implement the solution.

The local utilities believed that a solution was near, but many people felt that a water shortage was even closer.

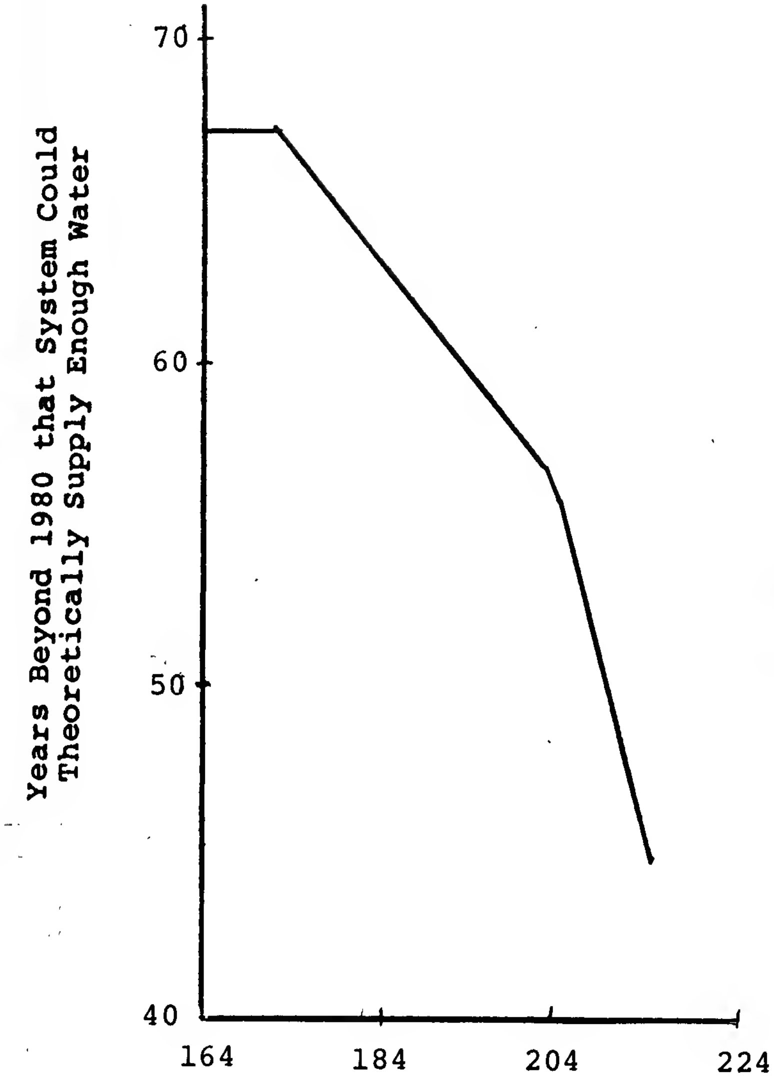


Exhibit D-1

The Trade-Off Curve for Upstream Reservoir Release and System Yield

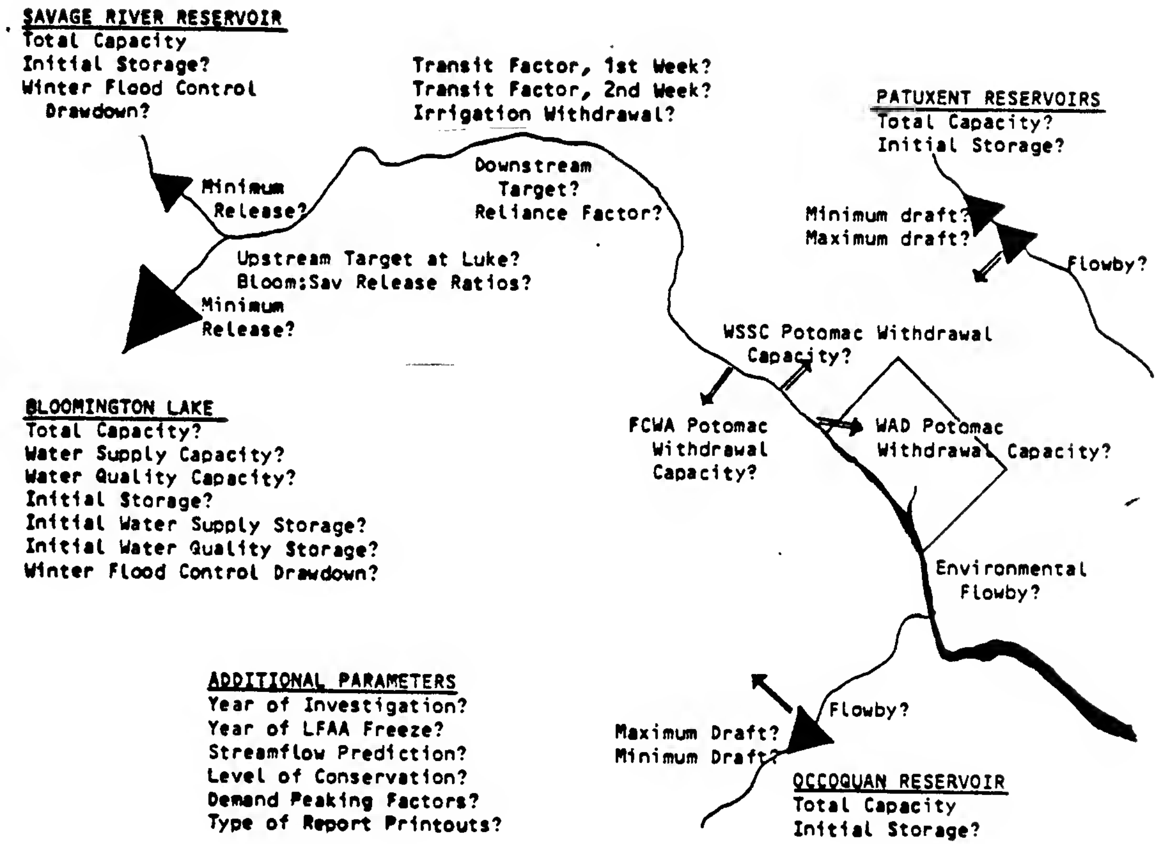


Exhibit D-2

Questions Asked of Utility Operators in Determining WMA Water Supply

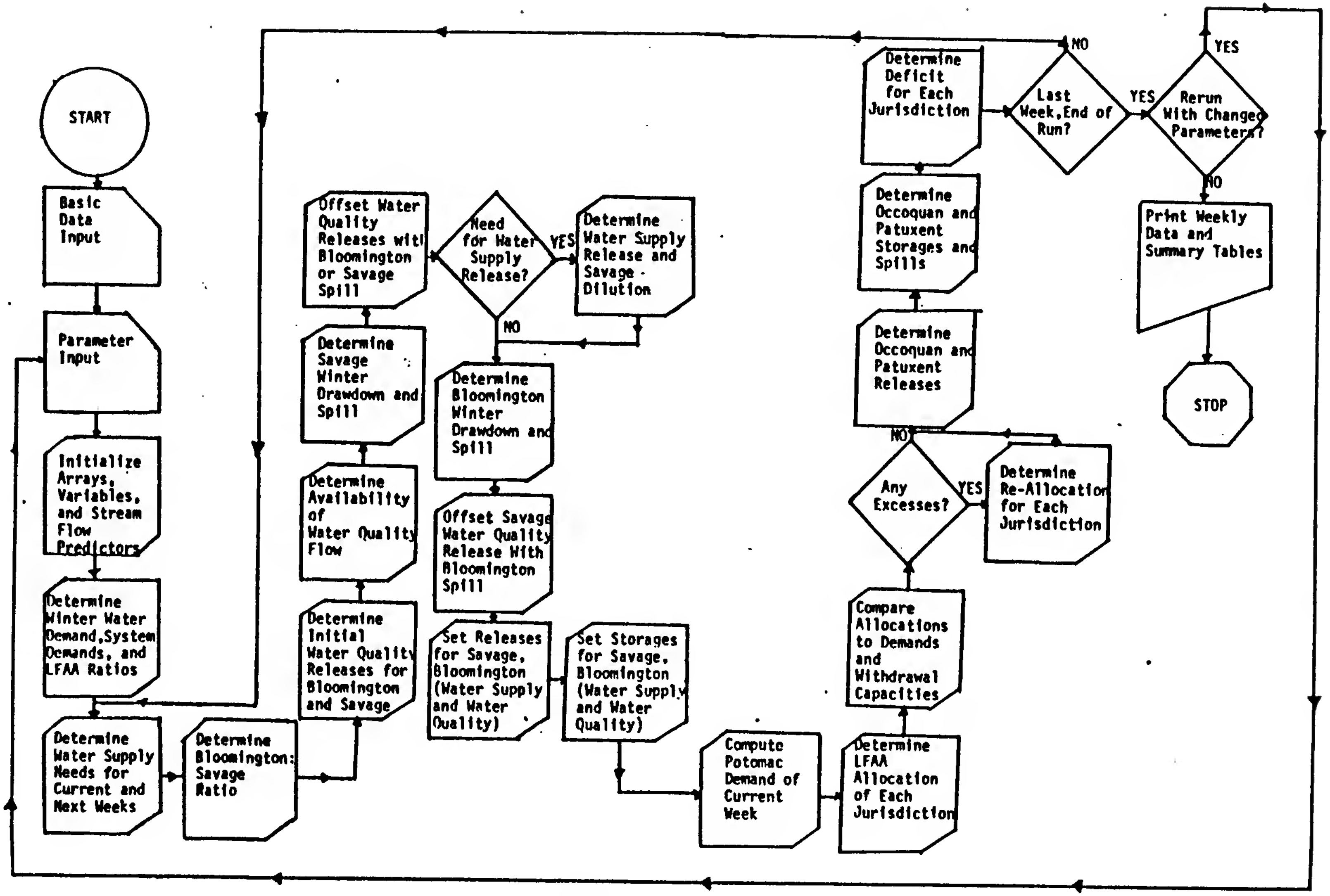


Exhibit D-3

Flowchart of Basic Operational Decisions made by PRISM Model

PART E: ATTEMPTS TO RESOLVE THE WASTED WATER PROBLEM

Formation of CO-OP

The local utilities were not as pessimistic as the Corps of Engineers in considering the regional plan of regional cooperation as the solution to the WMA water supply problem. Maybe this was because they were more desperate to find a solution, since their customers were about to go without water and the other local alternatives were very expensive propositions. In any case, in November of 1979, the local utilities decided that they needed to work together. They asked the ICPRB to form a Section for Cooperative Water Supply Operations on the Potomac (CO-OP), under ICPRB's Article III charter authority. CO-OP was composed of ICPRB commissioners from the District of Columbia, Maryland, Virginia, and West Virginia, and was supported by a technical advisory group comprised of representatives from the WMA's three major water utilities. The main purpose of CO-OP was to develop regional regulation procedures for water supply reservoirs serving the WMA. In doing so they were to integrate Dan's reregulation proposal, the PRISM model, the Corps of Engineers' regional plan, and the drought management concept.

Dan explains the problem facing CO-OP:

> The theoretically achievable supply (as determined by the Hopkins Study) significantly exceeds the projected water requirements (from the WMA). The raw water storage is adequate, but only if we can get it where it is needed and when it is needed. The problem, then, is one of providing adequate techniques and facilities for management of existing supplies rather than the problem of new supplies.[10]

The main problem that CO-OP faced in managing their existing supplies was how to accurately predict the amount of water to release from Bloomington Dam.

The Difference Rule

Previous studies done by the Corps of Engineers suggested that there was no accurate way to forecast the flow in the Potomac a week in advance. CO-OP, however, needed some basis for prediction, so they decided that a simple assumption was better than none at all. As they began experimenting with different forms of operating rules for releases from Bloomington Dam, they discovered that the difference rule, which was the simplest rule, was also the best. Dan explains:

> To determine upstream releases under this rule, the natural flow in the Potomac at Washington on the date of the release is subtracted from the total demand (including required instream flow) from all sources

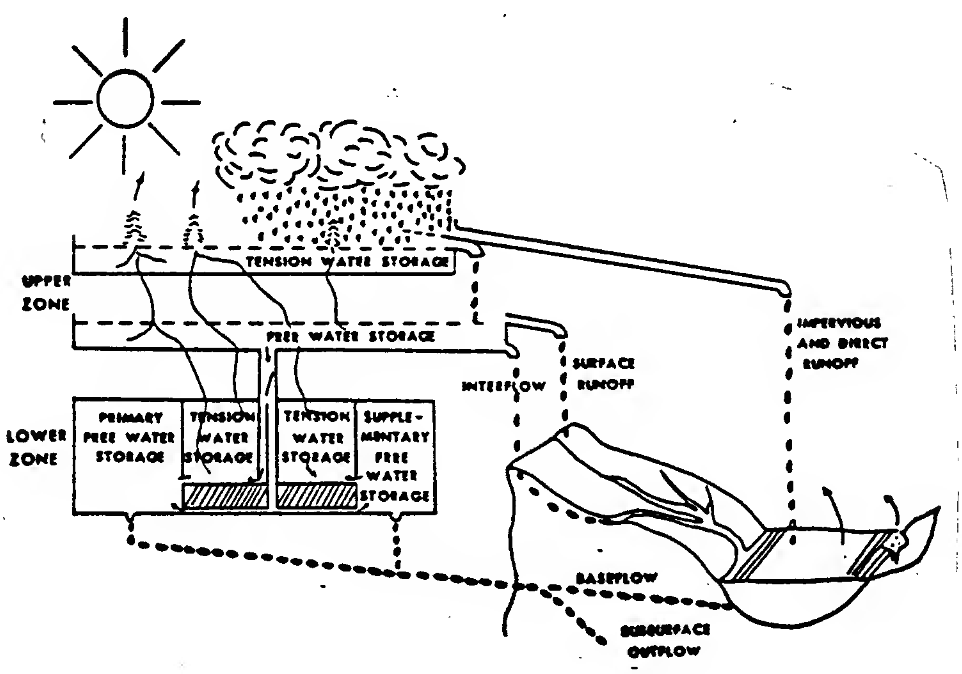
expected on the day the release will arrive. This is equivalent to assuming (or forecasting) that the flow will remain unchanged over the time of travel. The difference (hence "difference rule") represents the total additional water which will be needed if the natural flow remains constant. The difference is adjusted by subtracting the amount desired to be taken from the local reservoirs and adding a safety factor.[11]

This difference rule assumes that flow will not change over the travel time, which is fairly true in the Potomac where low flows are relatively stable. A safety factor still needed to be used, though, and inevitably water would be wasted.

<u>Refining PRISM for Better Release Forecasts</u>

The above rule was helpful to CO-OP as they began forecasting releases, but soon it was evident that better flow forecasts were needed. In an effort to achieve more precise streamflow predictions, they totally recalibrated PRISM to utilize daily operating rules as opposed to previous weekly rules. This was important because of three reasons: utilities operate on a daily basis; forecasts change from day-to-day; and water use varies daily. Although many man-hours were spent recalibrating the model, the added precision of daily operations was well worth the effort.

For greater precision of actual stream flow, CO-OP entered into an agreement with the National Weather Service to develop an accurate National Weather Service River Forecast System (NWSRFS) for the entire Potomac River Basin. This is basically a soil moisture accounting model which takes historical rainfall records and traces water movement through several different storage compartments representing soils in the upper and lower zones. An example of a simple soil moisture accounting model is shown below:



This model keeps track of how much water is in each reservoir and how much drains into the tributaries. The model is calibrated using historical data, and the parameters are adjusted until the model reproduces actual streamflow measurements previously recorded at USGS gauges. This system helped to forecast flow levels in the Potomac even more accurately, but still, even with these PRISM model refinements, the Bloomington releases could not be forecasted accurately enough.

The Problem Still Lingers

CO-OP made many interesting and applicable discoveries, as illustrated briefly above. Even with these innovations, however, one major problem still was yet to be resolved -- to ensure enough water downstream, the margin of safety for upstream releases from Bloomington Dam must be about 100 mgd. The Corps had to release this extra water to be sure that, even if there was hot weather and no rain during the five days of travel time, and even if record demands needed to be met, there would be enough water for everyone. However, since rain usually fell, temperatures are usually mild, and demands are usually average, seventy percent of the water released from Bloomington would usually flow by the intakes unused. In addition, since this extra release from Bloomington is in the Potomac, the average use of the local reservoirs was low and they stayed full while the level of Bloomington Reservoir dropped dangerously.

A Great Old Idea -- Construction of Little Seneca Reservoir

Bob McGarry, who previously tried to construct Little Seneca Reservoir as part of a local plan, decided to implement the reservoir into the regional plan. This idea incorporated into a comprehensive regional plan the flexibility which was so badly needed. Computer simulation revealed that releases from Little Seneca would reach the Potomac intakes in one day. This would eliminate the need for such a large margin of safety in the upstream releases from Bloomington, since releases from Little Seneca could be used to correct for forecasting errors the day before the shortage would occur. Now Bloomington could be on a tighter release schedule, and even if no rain fell during the week releases from Little Seneca would more than make up the difference. This reduced the average unused portion of the upstream releases from seventy to ten percent, and would allow the local reservoirs to be fully utilized in supplying water to the local utilities. Simply, not as much water would be wasted.

In addition to Little Seneca, Bob introduced into the regional plan another concept of his which previously had been incorporated into the Bi-County Task Force Study -- ideas pertaining to conservation. In order to help reduce demands of the WMA, he suggested that the utilities adopt the concepts of plumbing codes and pricing schedules. These were not passive measures which would only apply during drought conditions, as in drought management. These were

active measures which could be depended upon all throughout the year. As a result, the local utilities predict that by the year 2000 there will be at least a 10% reduction in WMA water demand.

The New Outlook

According to Corps of Engineers' predictions, the water made available by the service of Little Seneca would add enough water capacity to the total supply to increase the net safe yield to 950 mgd, meeting water demands through 2030. Almost as important, to Bob anyway, is that no longer could the E.P.A. object to the construction of Little Seneca because it might stimulate independent solution plans for more reservoirs from other utilities. This would be a comprehensive regional plan, one which solved the water problems of each utility.

The technological aspect of the WMA's water supply problem was now solved. To illustrate how the WMA water supply system might function during a drought, see Exhibit E-1. The figure displays the drought's progression through an entire season as the demands gradually increase and the available natural Potomac flows decrease. Across the top of Exhibit E-1 are listed the basic sequence of operations which could be taken to avoid potential shortages when demands begin to exceed supplies. These actions make the most efficient use of all sources from a regional perspective, and are quoted from the Army Corps of Engineers' Main Report, released in March of 1983. A summary of the WMA water supply situation as seen by local engineers in 1981 is given in Exhibit E-2.

This present plan is only the latest in a long line of technologically sound proposals, which started with the Corps of Engineers' sixteen dam proposal in 1963. Whether this current solution proposal, which looks appealing on paper, could be implemented by three independent utilities was yet to be seen. Many people, including the Corps of Engineers, did not believe that a regional solution using regional cooperation was possible, as indicated by the quotes listed at the end of Part D. Also, as shown in Part C, the Environmental Protection Agency was opposed to the construction of Little Seneca Reservoir, which was a vital element of the regional plan.

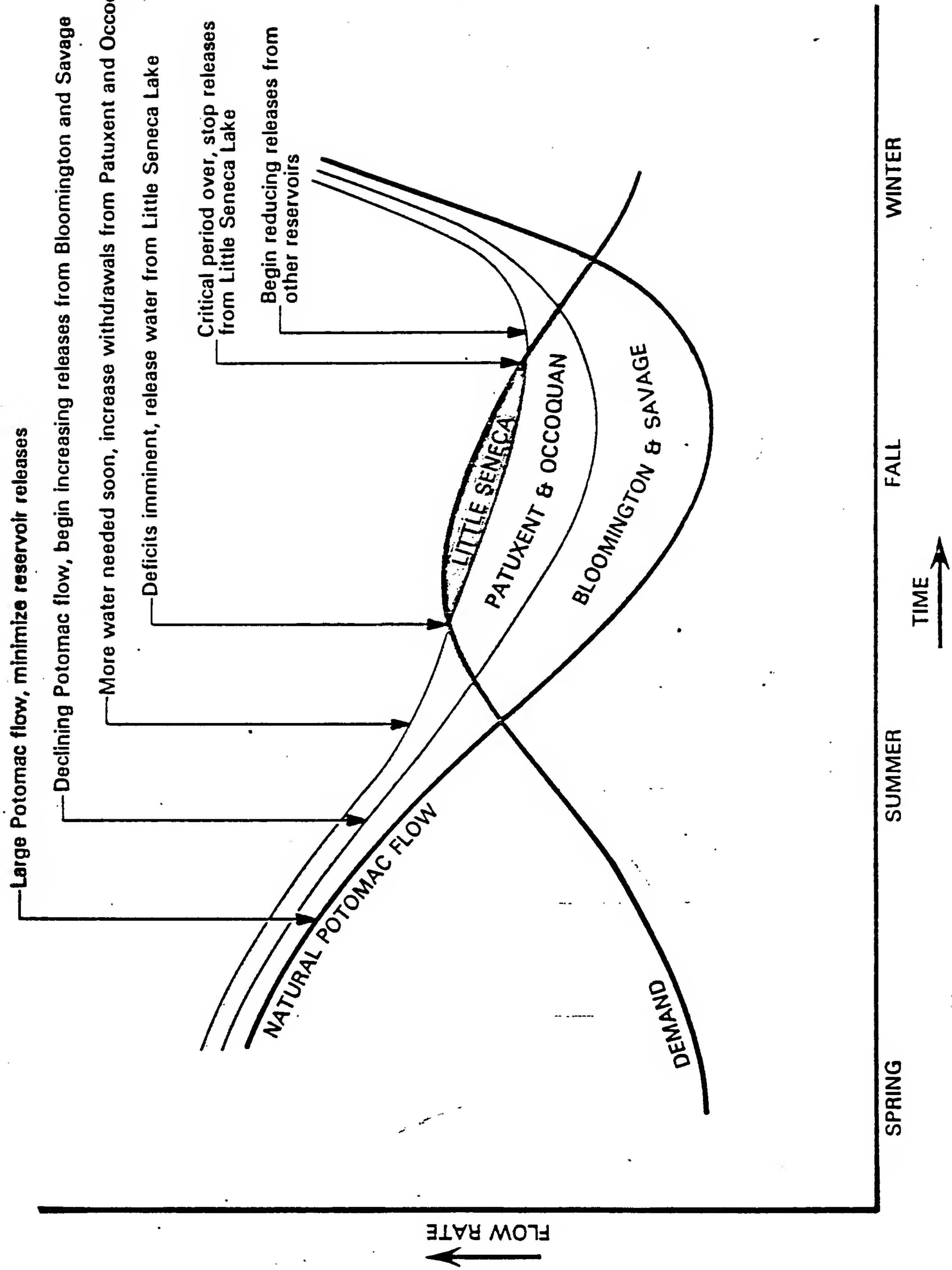


Exhibit E-1

Overview of WMA Water Supply Operation

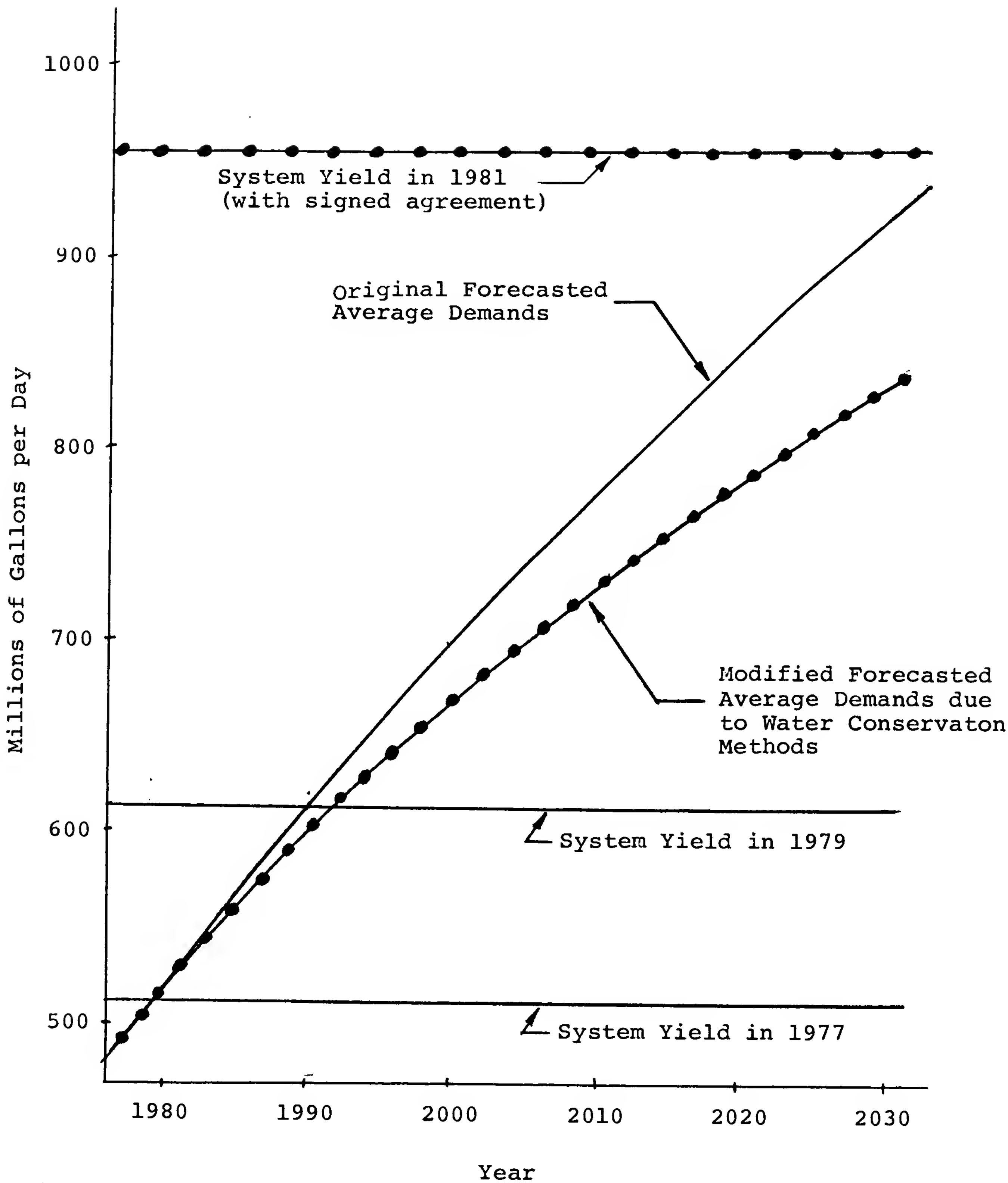


Exhibit E-2

Situation Facing WMA Engineers in 1981

PART F: ATTEMPTS TO REACH AN AGREEMENT

A New Task Force

Bob had worked on the WMA water supply problem too long and too hard to just sit back and watch another proposed solution die. In December of 1980, he wrote to the presidents of the councils of the District of Columbia, Fairfax County, Montgomery County, and Prince George's County and asked them to form the WMA Water Supply Task Force. They agreed, and in January of 1981 the second Task Force was formed using the first Task Force, the Bi-County Water Supply Task Force, as a model. The previous Task Force had worked so well that Bob decided to copy its structure. Bob again served as general manager of the Task Force, with the four council presidents as members and a citizens and technical advisory committees (CO-OP was adopted by the Task Force as the technical advisory committee).

Advice from CO-OP

CO-OP advised the Task Force of its research, the bulk of which was reported in Part E of this case, which showed that the Task Force should try to implement a regional solution to the problem. CO-OP brought before the Task Force some interesting facts to back up this suggestion. In the local and regional Corps of Engineers' plans which were reported in Part D of this case, the only structural difference between the two plans was that in the local plan a raw water pipeline would have to be built in 1994, while in the regional system a similar pipeline needed to be built around 2017 (refer back to the figure on page 24). The cost difference wasn't enough to justify choosing the regional plan because it was cheaper. In 1981, however, CO-OP studies (see Part E) subsequent to the Corps proposals found that improved management techniques, especially use of Little Seneca, eliminated the need of a pipeline in the regional plan. Now, since there was a large price difference between the two plans, CO-OP advised the Task Force that the regional plan be implemented.

The Task Force adopted the regional plan and declared that CO-OP be administrator of the release patterns dictated by the model, which itself would be treated as a contract. In this way a neutral party, in the form of Dan and ICPRB, would have responsibility for carrying out the proper drought procedures.

The Task Force contacted the utilities and persuaded them, in principal, to abide by the plan calling for regional cooperation. Still to be resolved, however, was how to gain E.P.A. permission for the project, how to share the costs of the project, and how to share the water within the WMA.

E.P.A. Reaction

Again the construction permit for Little Seneca Reservoir was submitted to the Corps of Engineers for approval. The Environmental

Protection Agency, which routinely reviews Corps of Engineers' permits, had 90 days to respond with approval or denial. No letters from the E.P.A. were received by the Corps within the allotted response time. The E.P.A. had no comment on the matter, indirectly giving the WMA permission to build Little Seneca Reservoir.

Utility Agreements

The regional plan, which could now be actively pursued, stipulated that the water in the Potomac River System be proportionately divided among the utilities according to the demands that each had to meet. In order to assure that this would happen, two agreements were incorporated into the WMA Water Supply Study. The Low Flow Allocation Agreement (LFAA), signed in 1977, was modified in 1982. This agreement provides an equitable means of allocating Potomac River water among the WMA users during low flow periods so that no area suffers disproportionate shortages. The agreement also provides for a review every five years to determine the fairness and reasonableness of the allocation formula.

The second agreement, the Water Supply Coordination Agreement, was established at this time by the three utilities. This agreement formalizes the region's commitment towards a regional solution both now and in the future. This agreement identifies the ICPRB, through Dan and CO-OP, as the appropriate agency to manage the PRISM model and dictate when and where the water releases should be made. With these agreements only one question was unresolved — — who pays for construction of Little Seneca Reservoir and any future costs of the system?

Return of the PRISM Model

The PRISM model was first used to determine if there was a solution within the WMA system, then it was used to convince utility operators that there was a solution, then it served as the contract which determined how much water each utility could withdraw. Now it would become an immense help in determining the allocation of costs. Dan Sheer explains:

> The issue of cost sharing remained, and once again the model provided a common basis for negotiation. CO-OP, as the keeper of the model, had no direct role in the negotiations, and thus remained "neutral." Each utility directed its own runs of the model, modified to allocate shortages which could occur under the operating rules which would be used if an agreement was not reached. The shortages were allocated using each utility's own interpretation of the riparian doctrine of water rights, and the Low Flow Allocation Agreement. Several hundred simulation runs were made, using different droughts and assumptions, before

> the utilities were satisfied that an equitable allocation of cost had been devised.[12]

The main problem with each utility making its own simulated drought runs is that, as every engineer knows, raw data can be manipulated. Cost-sharing is a difficult business, and the following example is not unlike what happened in this case. Suppose that all three utilities had equal demands to be met, so that theoretically each utility would have to pay a third of the bill. Invariably, when it comes time for contract negotiations, each utility will believe that they owe thirty percent of the cost and the other two utilities each owe thirty-five. This is because each negotiator is only trying to please his employer by keeping his costs down, and therefore underestimates the actual costs. Since each utility believes that the other two should each pay 35% of the costs, and 3 times 35 does not equal 100, it takes much longer than it actually should to sign a contract which nevertheless will read that each party will pay a third of the bill. The "reward" of these long negotiations is when each negotiator goes back to his boss and shows him the other utilities' estimates of thirty-five percent. Since the other two utilities believed that your utility should have paid thirty-five percent of the cost, and you actually only payed a third of the cost, the negotiator comes out looking like a shrewd bargainer.

The Final Agreement

Negotiations proceeded in the above way for almost a year, as Bob describes:

> It was a difficult process, there were many setbacks along the way, and at times there was certainly every indication that we would have to give up. But we kept on, and I recall, at one point, towards the end of the work on the agreements, we had 11 lawyers going over them word by word. Well, if it had been left to them, they would have met periodically and would still be meeting. But they were not allowed to leave until they had reached a solution that day. That takes dedication.[13]

Everyone involved in this project -- Dan, Bob, and many other people -- had the dedication that it takes to solve a thirty-year water supply problem. Once the final agreement was signed not only was the problem solved until 2030, but it was solved with the only new construction being that of a very small reservoir, at the cost of about thirty million dollars. There were six main clauses contained within the final agreement, as shown in Exhibit F-1. The agreement was signed on July 22, 1982. The only thing remaining is to build Little Seneca Reservoir, which is presently under construction and is to be completed in 1986.

Final Comments

Cooperation was the reason why this water supply problem was solved. The five reasons that Bob McGarry believes caused this successful cooperation are listed below.

A. The leaders of the three water supply agencies finally realized that the efforts of Congress and the Corps, though sincere, would not resolve the issue.

B. Elected officials who were eventually responsible for the solution were asked to form the two task forces, and it was they who made the decisions and recommendations in lieu of the utilities.

C. Citizen leaders were involved from the beginning and concurred in every decision.

D. Traditional planning concepts were abandoned and replaced by innovative thinking and incorporated the important concepts of risk management and regional system-wide operation.

E. There was a dedication on the part of several individuals involved in leadership roles to resolve the issue, and they persisted in spite of what, at times, seemed to be insurmountable technical, legal, or political obstacles. Perhaps this dedication to solve the issue is the most important factor.

The solution of the Washington Metropolitan Area water supply problem is attributed to many factors —— some of the major contributions are displayed alongside a timeline in Exhibit F-2. The official document assembled by the Corps of Engineers on this problem, the Metropolitan Washington Area Water Supply Study Report, should be completed by Fall, 1983. It will then be transmitted to Congress in accordance with the directives of the study's authorizing legislation —— Section 85 of the Water Resources Development Act of 1974 (Public Law 93-251). This legislation was shown in Exhibit A-5. It is expected that the utilities who signed the 1982 regional agreement will adhere to their contracts, and that, unless a drought occurs which is many times worse than the worst historical drought in the Washington area, the Washington Metropolitan Area should have enough water until at least 2030.

(a) WSSC, Aqueduct/DC and FCWA should purchase from the Corps of Engineers all water supply storage in Bloomington Lake and relieve the Maryland Potomac Water Authority (the original purchaser of the project's "present" water supply storage) of any obligation for repayment. Yearly repayment to the Corps for capital and operation and maintenance (O&M) costs allocated to water supply should be shared among WSSC (50 percent), FCWA (20 percent), and Aqueduct/DC (30 percent).

(b) WSSC, Aqueduct/DC, and FCWA should share the capital and O&M costs of the water supply portion of Little Seneca Lake, with WSSC assuming a 50 percent share, Aqueduct/DC assuming a 40 percent share, and FCWA assuming a 10 percent share. The costs of land for the buffer zone and for recreation should not be shared.

(c) The MWA utilities should share the O&M costs of Savage Reservoir, presently borne entirely by Allegany County, because Savage Reservoir releases will be necessary to neutralize acidic releases from Bloomington Lake. Annual shares should be repaid by WSSC (40 percent), FCWA (16 percent), Aqueduct/DC (24 percent), and Allegany County (20 percent).

(d) A regional agreement among WSSC, Aqueduct/DC, and FCWA should be formalized through ICPRB's CO-OP program to achieve the operational water supply objectives stated below:

(1) Maintain the risk of invoking the LFAA at less than 5 percent during the repeat of any historical drought.

(2) Maintain the risk of entering the Emergency Stage of the LFAA at less than 2 percent with full reservoirs on June 1.

(3) Maintain the risk of not refilling any reservoir used for water supply at less than 5 percent.

(4) Maintain the LFAA specified low flow over Little Falls Dam at 100 mgd.

(5) Minimize conflict between normal utility operations and drought operations.

(6) Provide consistency with the requirements of the LFAA.

(e) The LFAA should be revised to: (1) eliminate the provision that freezes the computation of each jurisdiction's low flow share after 1988, and (2) include Little Seneca Lake releases as flow subject to the allocation formula. These revisions should become effective only when Little Seneca Lake is operational and the regional operating agreement is in place.

(f) Cost for construction and O&M of any future MWA water supply project after Little Seneca Lake should be shared among the parties in accordance with the formulas below. Further, water from such a project would be subject to allocation according to the LFAA.

District of Columbia's Share $$\% = \frac{(A-B)}{(A-B)+(C-D)+(E-F)} x100$$

FCWA's Share $$\% = \frac{(C-D)}{(A-B)+(C-D)+(E-F)} x100$$

WSCC's Share $$\% = \frac{(E-F)}{(A-B)+(C-D)+(E-F)} x100$$

Where:

A = The average number of gallons of processed water pumped daily by the Aqueduct to all its customers from all sources (expressed in million gallons per day) during the month of July in each of the five (5) years immediately preceding the award of a contract(s) for the construction of the additional water supply facilities.

B = The average number of gallons of processed water pumped daily by the Aqueduct to all its customers from all sources (expressed in million gallons per day) during the month of July in each of the years 1981 through 1985.

C = Same as A, except substitute the number of gallons of processed water pumped daily by the FCWA.

D = Same as B, except substitute the number of gallons of processed water pumped daily by the FCWA

E = Same as A, except substitute the number of gallons of processed water pumped daily by the WSSC.

F = Same as B, except substitute the number of gallons of processed water pumped daily by the WSSC.

Exhibit F-1

Summary of Final WMA Contract

Historical Incident	Year	Ramifications of Incident
Potomac River Study Recommends Construction of 16 Reservoirs	19 63	
Report of Chief of Engineers Recommends 6 Reservoirs	19 69	
Interim Report Recommends 2 Reservoirs and Advanced Sewage Treatment Plant	19 73	
U.S. Congress Passes Water Resources Bill	19 74	Initiated Extensive Study of WMA Water Supply Problem
Formation of Bi-County Task Force (see Part C)	19 76	Unique Structure of Force with Politicians in Leading Roles
Public Survey Conducted by Corps of Engineers	19 77	Recommendations of Local Solution and Use of Water Conservation
Study by ICPRB and Dan Sheer (see Part B)		Abandoning Safe Yield for Volume Analysis; Theory of Reregulation
Johns Hopkins Analysis Using PRISM Model (see Part D)		Remodelling of Bloomington Releases; Confirmation by PRISM that there is Enough Water If Only Properly Managed
Bob McGarry Joins Task Force		Concepts of Drought Management and Little Seneca Reservoir
E.P.A. Refuses Construction Permit for Little Seneca	19 80	Stimulated Development of Regional Cooperation
Formation of CO-OP		Refining of PRISM Model, Incorporation of Little Seneca into Regional Plan
Formation of WMA Task Force	19 81	Acceptance of Regional Plan by Local Utilities, Politicians, and People of WMA
Agreement Signed, July 22	19 82	Solution of Problem
Corps of Engineers' Study Finished and Submitted to Congress	19 83	

Exhibit F-2

Timeline of WMA Project History

REFERENCES

[1]U.S., Corps of Engineers, Metropolitan Washington Area Water Supply Study, Appendix C, p. C-III-4.

[2]U.S., Corps of Engineers, MWAWSS, Appendix A, p. A-96.

[3]"Assuring Water Supply for the WMA--25 Years of Progress," in A 1980's View of Water Management in the Potomac River Basin, U.S. Congress, Senate Committee on Government Affairs, 97th Congress, 2nd session (Washington, D.C.: United States Government Printing Office, 1982), p. 46.

[4]Interview with Dan Sheer, Interstate Commission on the Potomac River Basin, Rockville, Maryland, 28 June 1983.

[5]"Potomac River Basin Cooperation: A Success Story," in Conference Procedings of Cooperation in Urban Water Management, (Washington, D.C.: National Academy Press, 1983), p. 92.

[6]Ibid., p. 95.

[7]U.S., Corps of Engineers, Metropolitan Washington Area Water Supply Study, Progress Report, Main Report (Baltimore, Md: Department of the Army, 1979).

[8]C. Haefele, The Washington Star, 13 April 1979.

[9]Loretta Nimmerrichter, Interstate Commission on the Potomac River Basin, Thames/Potomac Seminar, July 1979.

[10]U.S., Congress, Senate, Committee on Governmental Affairs, District of Columbia Water Supply Study, 96th Congress, 1st session (Washington, D.C.: Government Printing Office, 1981), p. 163.

[11]Dan Sheer, Assured Water Supply for the Washington Metropolitan Area (Rockville, Md.: Interstate Commission on the Potomac River Basin, 1983), p. 15.

[12]Ibid., p. 23.

[13]"Potomac River Basin Cooperation: A Success Story," p. 100.

ECL 261N

Educating Prospective Engineers for Public Policy

INSTRUCTOR'S GUIDE FOR A CASE ON

INNOVATIVE TECHNIQUES FOR MANAGING WATER SUPPLY

by

Gary Imm[1]

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Prepared as part of the 1983 Washington Internships for Students of Engineering (WISE) Program under the supervision of Dr. Barry Hyman[2]. All opinions presented are those of the author and do not in any way represent those of other individuals or institutions referred to in the text.

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This case examines the efforts of the Washington Metropolitan Area water utilities to supply enough water to its clients. It highlights the roles of two engineers--one who works for a local utility and the other whose duties at the Interstate Commission on the Potomac River Basin deal with monitoring and regulating the waters of the Potomac River System.

The purpose of this case is to illustrate to the students the importance of considering both the technical and the political aspects of an engineering solution. Technologically this case is indicative of future water supply problems that today's students will no doubt encounter. As long as demands rise faster than new supplies can be financed and constructed, better management of existing systems using techniques such as reregulation, drought management, and computer modelling will become more and more essential.

The public policy aspects of this case are just as important as any technological advances which were made. While the public policy environment is one that has an increasingly large impact on the activities of modern engineers, this dimension of engineering is rarely covered in typical engineering courses.

There are several modes of using this case; much is deliberately left to the instructor's choice. To increase the flexibility of the case and allow its use in more than one type of course, the case is organized to six main parts. The instructor may choose to omit one or more of these parts to fit the case into different allotted time frames and/or to provide a particular focus on some aspects of the case. The following paragraphs suggest possible classroom uses of the case.

Possible use #1: The instructor presents the information contained in the case in a lecture format to outline the problem, and makes the entire case available for more detailed study. The instructor could remove Exhibit F-1 and divide the students up into groups representing the different positions involved and mentioned in the case. The groups would be required to draw up a contract. Examination of the case and insight into the problems involved would be required of the students to become familiar with the technical aspects of the problem, before they could discuss what type of contract to draw up between the groups. The last part of the assignment would be to have a meeting of the groups to decide who pays for what and who gets how much water at what times. They should come up with a document like Exhibit F-1, although it might be totally different.

Possible use #2: The instructor describes the problem and discusses Parts A and B in a lecture format. Students would then be asked to go behond the 1990 solution to the problem. These solutions could be written or presented in a discussion format. After the discussion or collection of the written

solutions Part C could be discussed and made available. Students could then be asked to defend the E.P.A. position or to try to convince the E.P.A. to change their opinion. Next Part D would be introduced and the students asked to come up with a solution proposal based upon this new information. Hopefully something like the CO-OP would be recommended, although leading the students by pointing out what some of the problems are might be necessary. The final resolution could then be given after the students have come up with their alternatives.

Possible use #3: A basic computer simulation program similar to the PRISM model would be very valuable to have on line on a computer, especially if the students themselves were involved in modelling the program. This would be an excellent way to introduce students to the techniques of computer modelling. The running of the program could be done as a class demonstration or teams of students could do their own run with their own data. Each team could represent one of the water authorities involved and affected by the regional agreement.

Possible use #4: The instructor presents the entire case to the students and discusses with them the management techniques used to solve the water supply problem. To give the students an opportunity to apply what they have learned, the instructor could assign them to analyze an existing water supply system other than the WMA system. Using the techniques which were instrumental in solving the WMA problem, the students could determine for their assigned system if there exists a more efficient way to manage the water supply than the method which is currently being used for analysis (such as independent safe yield analysis). Also, it might be interesting to bring in a speaker from a local water utility, to discuss their views on reregulation, drought management, and system coordination.

The following questions are designed to assist in the discussion of specific topics. More effective discussions may be generated if questions about the project are posed to students before they are discussed or answered in the paper. In this manner the approaches taken by the students and those actually pursued can be compared.

PART A: DEFINITION OF THE PROBLEM

1. In the early stages of this case the public was not given a chance to become involved in the decision-making process and the plans went nowhere. Discuss the advantages and disadvantages of direct public involvement at the beginning of the decision-making process.

2. The Corps of Engineers, whose business is building dams, is usually the organization who makes the recommendations pertaining to which water resource plan should be implemented for the future needs of an area. Is it possible that this creates a bias within the Corps when it comes time to decide which plan to endorse?

3. Discuss how the plan of 1963 would have been used to solve WMA's water supply problem.

4. Early estimates of the amount of minimum flowby needed ranged from 0 to 1200 mgd, with the final number decided to be 100 mgd minimum flowby at Washington. Why the need for a minimum flowby?

5. Earlier proposals emphasized upstream reservoirs as the solution. How would you convince a farmer upstream to flood his land so that bureaucrats in Washington can have a dependable water supply?

6. How could the results of the public opinion survey of 1977 be used towards development of a feasible solution?

7. It is clear from Exhibit A-3 that there is plenty of water to satisfy all needs through 2020 even with 1930 drought conditions. The only problem is that the 6500 mgd surplus in spring is not of much use when the 400 mgd deficit in fall arrives. Discuss ways to evenly distribute the water surplus throughout the year, so that, instead of extreme surpluses and deficits, a constant supply of water can be maintained. (Hint: The length of the critical period of the local reservoirs is nine months, while the length of time that demands have been greater than Potomac River flows is only four months.)

PART B: THE REREGULATION CONCEPT

1. The WSSC and the FCWA service areas proved to be ideal for implementing the reregulation concept. Discuss reasons why these areas were so suited to reregulation. Are there ways to adapt "non-ideal" service areas so that they too could implement reregulation (for example, an area that does not have access to both a river and a reservoir)?

2. In Exhibit B-1 why do the drought flows increase with increase in drought duration but decrease with increase in frequency occurrence?

3. Raw water interconnections were considered too expensive for solution of the WMA problem. Had they been used, how would they have solved the problem?

4. Referring to Exhibit B-2, does it make a difference if the off-stream storage is located on the major source or the minor source?

5. Dan's volume analysis showed that the WMA water system would have more than enough water in the year 2000. If this is correct, why does Exhibit B-3 show that WMA's water needs are only solved through 1990?

PART C: CONTRIBUTIONS OF THE BI-COUNTY TASK FORCE

1. The structure of the Task Force, with politicians at the top receiving public input and making key decisions on critical issues before the design process is started, was a major factor contributing towards solution. However, since engineering projects usually take time to develop and public officials are generally in office for only a short time, wouldn't leadership changes (especially party changes) severely prolong the design process? Also, is there a possibility that task force involvement could become a major issue in election campaigns (for example, "Elect me and I won't turn your front lawn into a water supply reservoir")? Discuss ways to prevent these problems from happening. In this case the engineers involved expressed that they were concerned that this might happen, but luckily all major decisions were made in off-election years.

2. In most engineering work the theoretical answer is calculated and then a large margin of error is allowed for through a "safety factor." In drought management an opposite approach is taken, where the calculations are made and the amount of risk which is to be taken is determined, mainly to make the solution more economically feasible. Discuss ways to justify the amount of risk taken versus the amount of money saved, not only as it applies in drought management but also how it affects other engineering disciplines as well.

3. Examine the risks and the benefits involved in the three scenarios of Exhibit C-1. Which scenario would you choose?

4. Discuss the problems of flexible reservoir operation, especially environmental problems of rapidly releasing

a large amount of water from a small reservoir.

5. What were Bob's options at the end of Part C? Which option would you choose, and why?

PART D: THE PRISM MODEL

1. Money is a very important commodity. If the total annual cost for the utilities of the regional plan is lower than the annual cost of the local plan, why didn't the utilities automatically choose the regional plan?

2. The only structural difference between the local and regional plans is that two different pipelines are to be built, one in the local plan in 1994 and one in the regional plan in 2017. If these pipelines are relatively equal in cost, then why is the regional plan one million dollars a year less than the local plan?

3. Examine the advantages and disadvantages between the independent operation of the local plan and the system operation of the regional plan.

4. In Exhibit D-1 the curve on the graph is horizontal from an upstream reservoir release of 170 mgd down to about 70 mgd. Why does the curve stop sloping here when it is steeply sloped from 170 mgd upward?

5. Discuss possible solutions to the problem of too much water being wasted from the Bloomington Dam releases.

PART E: ATTEMPTS TO RESOLVE THE WASTED WATER PROBLEM

1. Why was Bob eager to implement Little Seneca Reservoir as part of the regional plan? Since construction had not yet begun, any potential local reservoir site could have been chosen to be part of the plan.

2. Discuss the advantages and disadvantages of the two conservation theories used in this case--plumbing codes and price fixing. Why were these concepts used in place of the previously popular theory of drought management?

3. Compare Exhibit E-1 with Exhibit A-3, especially noting the natural Potomac flow line and the modified flow line which resulted from the regional plan.

PART F: ATTEMPTS TO REACH AN AGREEMENT

1. Why was it so important that a neutral party, in the form of ICPRB, be in charge of coordinating the proper drought procedures?

2. The PRISM model was important because it made people familiar with the drought operational procedure and because of its usefulness in helping to allocate costs. It was valuable because the utilities trusted that it accurately reproduced drought operations. How could the researchers at Johns Hopkins be positive that their computer model dictated on paper what actually would happen throughout the Potomac River Basin, especially when the consequences of being inaccurate are so devastating?

3. Discuss reasons for the action taken by the E.P.A. on the second permit review. Why didn't the E.P.A. simply send a letter back to the Corps of Engineers giving them their approval, instead of sending nothing at all?

4. What would have happened if the WSSC had received permission to build Little Seneca Reservoir and had solved their problem independently? Consequently, was the E.P.A. justified in their initial recommendation of permit denial?

5. Examine the logic of the WMA contract of Exhibit F-1, particularly section f.

6. In hindsight, compare the final solution of the WMA problem to the previously proposed solutions of Part A. Not only are the cost savings significant (30 million vs. 200 to 1000 million), but the environmental savings are great as well.